Metals and Alloys

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PRODUCTION • FABRICATION • TREATMENT • APPLICATION

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Metals and Alloys

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This Month

Every Month

Metallurgical Engineering Digest

Are You Heat-treating Parts That Require INDIVIDUAL HANDLING?

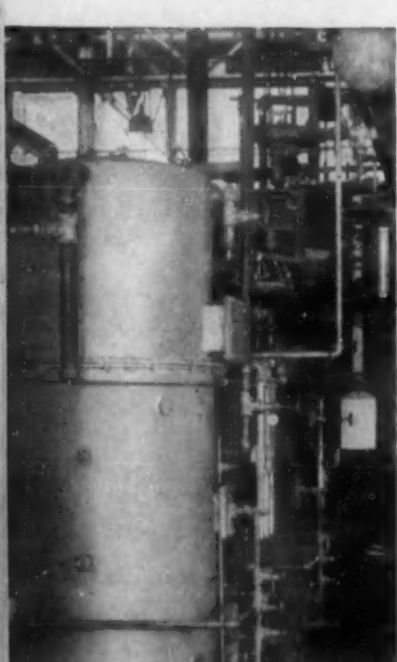
That's the Job for a ROTARY Hearth if you want

1. Accurate Hardening

2. Continuous Operation

Very little labor is required for operation. Charge and discharge doors are together so one workman can tend both

—and for NO DECARB Use a G-E Furnace with Drycolene



Battery of drycolene producers connected to common header for supplying atmosphere to a group of furnaces

FOR heat treating high-carbon, alloy-steel parts decarb free, General Electric now offers a rotary-hearth furnace that can be used with drycolene.

This furnace affords an easy and simple method of hardening parts that must be fixture quenched. Parts that require careful individual handling, such as gears and shafts.

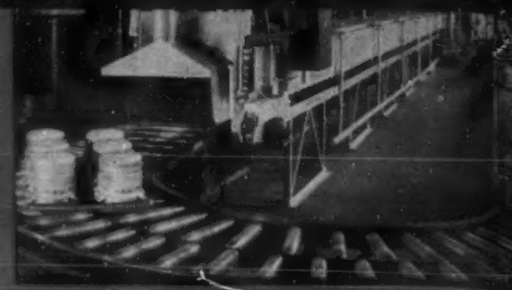
With this furnace and drycolene producer you can be sure of getting uniformly hard work without decarburization, and in one continuous operation.

If you have a heat-treating problem, get in touch with the nearest G-E office. Our engineers will make a study of it, and recommend the right furnace for the job, selected from dozens of tested and proved G-E heat-treating equipments that are available. *General Electric, Schenectady, N. Y.*

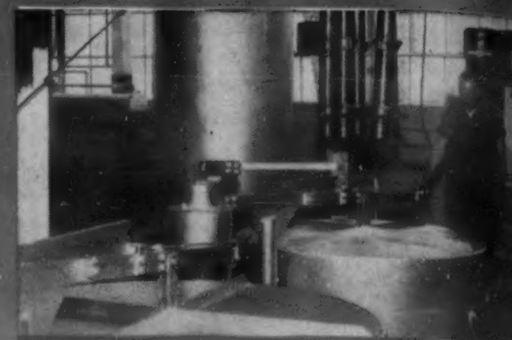
BUILDER OF FURNACES FOR PRACTICALLY EVERY INDUSTRIAL NEED

The Navy "E", for Excellence, has been awarded to 93,780 General Electric employees in six plants manufacturing naval equipment

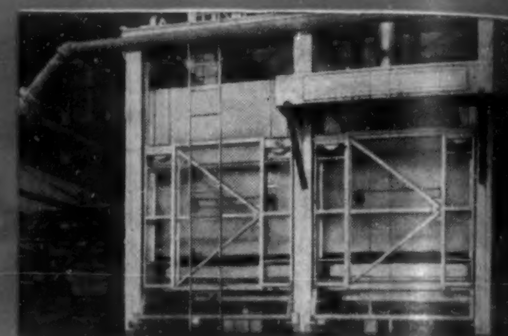
GENERAL ELECTRIC



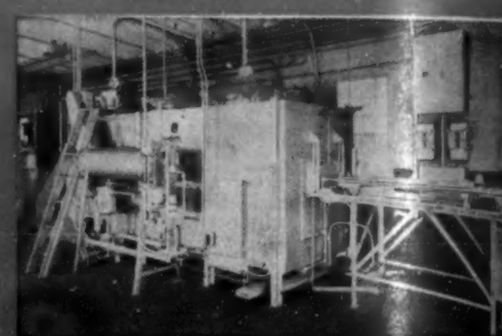
ROLLER-HEARTH FURNACE



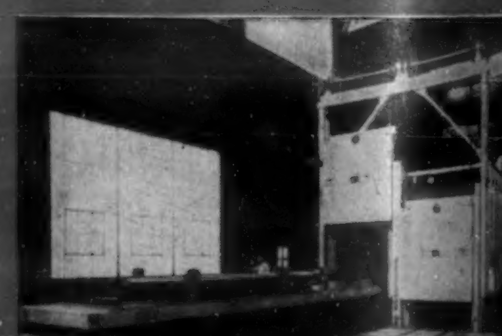
PIT FURNACE



ELEVATOR FURNACE



CONVEYOR FURNACE



CAR-BOTTOM FURNACE

PUSHER FURNACE

BOX-TYPE FURNACE AND ATMOSPHERE CONTROL EQUIPMENT

The Production Front

by Harold A. Knight
Associate Editor

More throwing out the window of alphabet governmental agencies hinted. . . . Accomplishment of production goals confused. . . . Substitutions sometimes swing back to originals. . . . Don't scrap old machinery if it can be adapted. . . . G. E. recovers metal scrap from ashes. . . . We intend to keep copper miners underground. . . . Modern plant has streamlined, built-in, salvage department. . . . Alloy steel may be 20 per cent of total in 1934. . . . Steel is not scarce in last analysis.

Speed often runs away with us. . . . We'll come out okay—Look at Valley Forge! . . . Renegotiating of war contracts outlined as to policy. . . . More coordination between U. S. and British steel production expected. . . . "Purp" has its limitations. . . . Typewriters to be made in one plant only. . . . Brazil has mineral resources. . . . Accidents are production leak. . . . Enemies lack copper. . . . Scrap collecting takes ingenuity and sweat. . . . Critical materials shift. . . . Lead becomes No. 1 plentiful metal. . . . FUD supplements SWPC.

Tactics Along the Front

"Save, Simplify, Substitute" is the slogan adopted by an engineering society, a slogan which, incorporated in a coat-of-arms, appeared effectively on the cover of a technical magazine recently.

This slogan well compresses the underlying goal along the entire Production Front. Slogans and catch phrases are an important adjunct in all national crises. They are the words that inspire at the time and go down in history. There were "Damn the torpedoes!" from Farragut; "I'll fight along this line if it takes all summer!" from Grant; "Sighted Sub—Sank Same!" from today's vintage.

Moreover, the "Save" slogan above has a hard and practical ring. In the same category is a homely slogan that determines what shall be manufactured and what is too civilian: "Will it fly, float or shoot?", quoted by William E. Arnstein, chief of "Purp."

Trial and Error at Washington

Trial and error still rule in Washington. One hears constant rumors that they will throw out all or most of the alphabet agencies and start all over, credible because of so many previous discardings (OPM out, and WPB in, for example). Many feel we should have copied more from the British, who had already gone through trial and error pains. Or, perhaps we should have applied more lessons we learned from the first World War.

Confusion has existed, as to whether we have lived up to our production goals, those high in authority having made contradictory statements. Final impression is that for 1942, as a whole, over-all goals will have been achieved.

In the scramble for substitutes, perhaps not enough foresight has been used to select a material that in turn, will not become scarce. Thus, many grades of lumber, such as used in making ammunition boxes, have become scarce. Apparently clever was the stove manufacturer who uses only a thin skin of steel, with the major portion of ordinary clay.

Material Need Last Only for "Duration"

The simplest and most abundant materials are the best, where they serve the purpose for the duration. Much of the world lives in mud or

(Continued on page 376)

adobe huts, with thatched roofs—perfect materials because supplies are inexhaustible.

Tungsten was one of the early metals to become scarce, with molybdenum a trump card substitute. They do say now that moly looks scarce with tungsten freer in supply, with a possible trend back to the original. A few months ago, nickel went through the same evolution—almost scarce as hen's teeth, then freer in supply. Wise men predict there will be considerable see-sawing until materials get fairly stabilized.

In the fever to scrap, there may be danger of breaking up machinery that can still be adapted to active service. A month ago we told of steel mills, converting strip mills to plate manufacture, using some World War I machinery that had had its "face lifted."

In a Timken plant, a machine is being made to "double in brass." A bending roll machine periodically has two wheels replaced by another two, one equipped with a circular knife, through which is run scrap power cable, which separates the rubber coating from the copper core, thus producing two critical waste materials.

Recovers Scrap from Ashes

New methods of recovering waste metals are heard of constantly. At a General Electric major works shop, refuse and rubbish are used for fuel. Ashes are passed through a ball mill or grinder; a magnetic separator takes out ferrous materials; a concentration table sorts out finer particles. In 1941, 624,000 pounds of iron, steel, brass, copper and aluminum were saved, a return of $10,000.

A new way of recovering the "salamander" from a blast furnace was developed by an Ohio steel tube maker. Salamander is iron that lies below the tapping hole and solidifies when the furnace is blown out. It is usually removed by dynamite, requiring two weeks minimum of valuable relining time. Now, a hole is drilled up through the furnace foundation and the melted salamander drawn off and cast in pigs on a sand floor. Thousands of such time- and material-savers could be mentioned.

We Must Keep Miners Underground

Meanwhile, labor gives increasing problems, with emphasis on shortage of copper and zinc miners. Paul V. McNutt proposes to raise their wages and improve their living conditions. Of the original 25,000 copper miners, 5,000 have left for higher paid jobs. Lieutenant-General Brehon B. Somervell has suggested that miners of coal, iron and gold be transferred to copper mines—but this, perhaps, looks better on paper than underground.

Salvage seems destined to play a more important role permanently. A new plant at Chicago is featured by its streamlined salvage department, with its modern collecting, sorting and handling equipment and provision to ship its scrap back to the steel mill daily.

An outstanding impression of the trend of things is the rapid ascendancy of alloy steel. Emergency steels provide for spreading thinner what alloying metals are available. This means a total over-all much larger production of alloy steel.

In 1942 alloy steel will amount to between 8 and 9 per cent of total tonnage; in 1943 it will reach 20 to 21 per cent, according to Albert L. Kaye, Alloy Bureau, Metallurgical Division, Carnegie-Illinois Steel Corp.

Chicago, at a meeting in that city to consider NE steels.

All Roads Lead to Steel

Just as in old times they said: "All roads lead to Rome," so on the Production Front do all—at least many —materials substitutions lead back to steel. Thus, steel cartridge cases and shells in place of copper place an added burden on steel. Tom Girdler has predicted that use of stainless steel in airplane construction, particularly large airplanes, will increase in importance each year. Steel continues to do most of the drudgery in this war.

Yet the steel situation is not without hope. The best minds say there is no true shortage of steel—merely a faulty distribution and lack of balance. Too many war plants got into production sooner than scheduled and produced more than their quotas, leaving large quantities of steel-made parts waiting for other parts in the same ultimate assembly to be made.

Two Weeks from Junk to Plates

A housewife junks a rusty clothes hamper. In 14 days it can be—and often is—reborn as a finished plate, ready to become part of a Liberty ship. (Authority: American Iron and Steel Institute.)

But, as hinted above, even speed can get out of hand and steal the whole show.

Finally, today, of course, we lack perspective. Bickerings between labor and labor, labor and management, WPB and Munitions Board, ad infinitum—often cloud the wonderful accomplishments and progress we, as a nation and part of a combination of nations, are completing.

Doubtless the ragged, barefoot soldier at Valley Forge felt it was all a useless, obscure, hopeless enterprise in which he was engaged.

But history has thought otherwise!

FUD Supplements SWPC

Instead of trying to get war work for small business threatened to be put out of business through curtailments, the War Production Board has begun to work the other way around through its Facilities Utilization Division, headed by W. B. Murphy, who conceives his job is to serve the Army, Navy and Maritime Commission in finding facilities for war work. It takes the place of the Contract Distribution Bureau, OPM and its successors.

How the program works:

(1) When a Government procurement agency is looking for a contractor or subcontractor to do a given job, it contacts FUD, outlining the work;

(2) A group of experienced production engineers confers about the assignment, recommends a prospective contractor, or assigns one of its staff to make further inquiry.

(3) Discusses the task with the prospective contractor, studies in detail his plant, equipment, personnel, and other production factors; and

(4) Gets the Government procurement officer and the prospective contractor together.

"Industry throughout the country is doing a remarkable job in using ingenuity in retooling old machinery for these new jobs," Mr. Murphy told METALS AND ALLOYS.

Thus, one branch of WPB, relating to small plants, wants only to serve ordnance; the other branch, pertaining to small plants, wants only to serve those plants.

PRP By No Means a Cure-All

Called the "white hope" of the War Production Board, the Production Requirements Plan (PRP) is not the lusty entity that championships are made of. In essence, it is a plan for collecting materials inventory data, and its chief instrument is the PD-25A form for quarterly reporting by industry:

(1) Requirements for materials, and

(2) Inventories on hand.

The job of analyzing these forms, being currently reported by more than 27,000 companies, has become prodigious. The stupendous number of reports is only a part of the problem. Many manufacturers are not clear as to how to make out the reports, some ending with duplications of tonnages, others winding up with underestimates.

The PRP is designed for manufacturers using more than $5000 worth of materials a quarter. To broaden the scope and include all manufacturers, WPB has announced the Limited Use Materials Plan (LUMP) for everyone else.

Some WPB executives realize that taking inventory, *per se,* is not the answer to getting the right time. The Army & Navy Munitions Board, which has locked horns with WPB over conflicting prerogatives, is looking on with deep interest. Failure of WPB to develop a method of materials flow to arms factories will be its signal to take over this basic job—WPB's most important function from here on.

Typewriters Soon Made in One Plant Only

War Production Board put the whole typewriter industry under a plan of concentration of production. Begun several months ago in a small way with the stove manufacturing industry, the typewriter scheme is destined to be a pattern for other industries, WPB spokesmen told METALS AND ALLOYS. Only one company will be allowed to continue the manufacture of typewriters under Limitation Order L-54-a, as amended August 4th. All other makers will be out of the typewriter manufacturing business on October 1st, except for parts built to a schedule.

The Woodstock Co. will be permitted to continue, since other companies are better adapted to build munitions. Learning of this decision, typewriter manufacturers have been working hard to get enough munitions business to keep their plants in operation. Some are still making special types of machines for military uses, however.

This scheme was projected for the automobile industry, but after Pearl Harbor the government decided that car manufacturing would have to be curtailed and the industry turned into a vast arsenal for the United Nations.

Let's Coordinate U. S.—British Steel

Armament production is using such large quantities of steel so fast that the War Production Board has begun a careful study of the British method of steel control, to determine what factors might be adopted in this country.

Combining the military and navy requirements of both countries, and combining output of steel mills to best fit those requirements, is the notion of

some WPB officials. Others believe that a simpler solution would be to exercise more thought on shipments of types and shapes to Great Britain, and possibly shipping certain types back to this country on empty convoy ships.

At any rate, Donald M. Nelson, WPB chairman, has asked that the American group be assigned to study this problem to effect more coordination.

In the meantime, however, a group of U. S. steel experts has begun such a study and made a preliminary report to the Government.

Lead: Exception That Proves the Rule!

Lead is the one major metal that is too plentiful rather than too scarce. Accordingly, it is logical to attempt to use lead in place of more critical materials where possible. Lead Industries Association, the trade organization of that industry, is active in promoting substitutions. Both the Army and Navy are considering seriously possibilities of lead.

Plumbing pipes and fittings in Service buildings are the first obvious use, such as army barracks, in place of iron and steel. Also in water service, in connections from the street to the house, it can easily supplant copper, iron and steel.

Couplings for asbestos piping, formerly of copper and bronze, can be made of 3 per cent antimonial lead, which also can serve in place of brass covers on drum traps in the bathroom.

Lead alloy flashings on buildings can easily supplant copper.

Nickel and iron are usually in batteries for miners' lamps, but lead-acid batteries would probably serve well. Lead in the place of zinc as fusable elements of electrical fuses have proved practical, though redesign of fuses is necessary.

The Maritime Commission has ordered practically all bearings made of lead base in place of tin. Ammunition boxes, first made of tin plate and later terne plate, are now being made of fiber boxes, made moisture-proof by a lead application. Lead in the place of rubber in the chemical industry for vats and containers is a "natural." Red lead paint in place of zinc chromate paint is another logical substitution.

Almost all plans for substitution, actual and contemplated, involve small tonnages by themselves, but loom impressively in aggregate. Consumption of lead has dropped one-third from the peak of last winter. Only about two-thirds of lead available from all sources (domestic, imported and secondary) actually goes into consumption, most of the rest being accumulated by Metals Reserve Corp.

Only a month or so ago the Army listed lead as a metal to conserve. Since then it has been placed in Class III on the critical metals list—meaning least critical.

They tell the following story (true or false?)—it makes a good story, at least—about a meeting at Washington between lead producers and WPB. The WPB chairman was reading off a list of inquiries for lead which had come to him: "A asks for 20 tons; B inquires for 30 tons." He looked up and the lead producers were yawning.

"C," he continued, "asks for 1000 tons. (Then he read off the various specifications). When the chairman

looked up again the room was empty. Each producer had run to the telephone to try to sell C.

Policies in Renegotiating War Contracts

Although industry generally believes that renegotiation of war contracts should be undertaken with careful reference to income and war excess profit taxes, the Army, Navy and Maritime Commission issued a joint statement of policy. Basic points:

(1) The right of industry to make a reasonable profit is recognized as fundamental. Abnormal business risks will be taken into account.

(2) Overall profits before taxes on armament items will be the basis of negotiations, rather than the individual contracts themselves.

(3) Neither detailed audits or complete examination of the contractor's books or records are contemplated.

(4) Only one price adjustment unit will negotiate with any given contractor. Usually it will be the Army, Navy or Maritime Commission, depending upon which of these procurement agencies is taking the largest share of the manufacturer's production.

Among the factors that will be variable, but which will be considered in renegotiating, will be: (a) inventive contribution, (b) rate of production, (c) quality of production, and (d) economy in the use of materials.

Other variable factors that will be considered include: (a) increases in labor rates, (b) increase in the cost of materials, (c) inexperience with new armament products, and (d) delays in getting materials.

The other two procurement agencies will renegotiate along the lines set up by whichever of the three handles the original renegotiation. Army renegotiating boards will work in the manufacturing areas, and the Navy and Maritime Commission will do their work in Washington. Such factors as over-extended financing will be considered, the joint policy states.

In general, the policy has more appeal to business men than most of the pronouncements from the Potomac. Renegotiators are admonished to see that "business will be assisted, insofar as practicable, to emerge from the war in condition to resume peacetime operations quickly and vigorously."

Our New Ally Has Mineral Resources

Now that Brazil has joined the United Nations, we will look twice at her natural resources. Of course, her metals, rubber, coffee, etc. have been available to us in her role as neutral. However, an ally in war supposedly becomes a much greater asset than when merely a neutral. There is less attention to the profit motive, more speed and cooperation in delivery.

Brazil's entry comes at a time when manganese supplies in other quarters are precarious. The richest sources in the Caucasus are threatened by Germany. Sources in India are jeopardized by Gandhi's revolt.

Brazil's mineral production has multiplied eight times in the last decade. Though her resources are not fully explored, known deposits, besides manganese, are iron, bauxite, chromium, zirconium, molybdenum, beryllium, titanium, nickel, tungsten, lead, copper, zinc, mercury, asbestos, platinum, gold, quartz crystals, diamonds and many other precious stones.

Brazil owns 22 per cent of the world's iron ore reserves, equal to the best produced by Sweden. New steel mills under construction will have a capacity of finished steel products of 300,000 tons in 1943, with an eventual capacity of 750,000 tons.

Never having been a great producer of metals, Brazil has been ultra modern in salvaging what she has. Now salvage shops, very well equipped, are in reality small manufacturing plants, where salvaged materials are important raw materials.

Old rails, no longer serviceable, are being used for light transmission line poles in rural zones. Scrap lead is placed in refining crucibles and given a quality of virgin lead. Tin in solders is being reduced in content as in the United States.

Previously, 85 per cent of Brazil's steel needs was imported, so salvage has become highly specialized. Steel cross-arms on light and telephone poles are being replaced by wood.

The Rio de Janeiro Tramway Light & Power Co. lists 36 types of transfers from a primary use to a salvage use. Thus, worn-out gear cases of streetcar motors are used for making washers, saving 3 tons of new sheet metal a year.

Accidents, Another Production Leak

Plugging up all leaks is the order of the day, whether in the form of waste of materials, machines, or manpower. Industrial accidents are always a lamentable form of waste, not only because of the loss, temporary or permanent, of the work of the employee, but because it always works hardship on others, particularly if the injured is head of the family.

Of unusual importance, therefore, are the studies of the National Safety Council, Inc., Chicago, now in pamphlet form, on the 1941 records of accidents. There are separate reports on the steel, foundry and non-ferrous metal industries.

In general, less accidents are suffered in the larger plants, usually because of better safety organization and education. In all three of these branches of industry both frequency and severity of accidents in 1941 were slightly higher on a percentage basis than the year before, though far less than in 1926, the beginning year for the study. The reason for the 1941 rise is presumably the period of transition from peace to war industry and the lack of skill in the unfamiliar techniques.

In the steel industry, the frequency rate was one half the average for all American industries, while the severity rate was 14 per cent above the average all-industries rate. Both frequency and severity rates were 5 per cent higher than in 1940. A high proportion of injuries involved hoisting equipment. They were most frequent among grinding machines, power presses, lathes and drilling machines. Corrigan, McKinney Steel Co., Cleveland Republic subsidiary, holds the outstanding safety record: Injury-free man-hours worked, 5,326,144.

In the foundry industry, injury rates increased 31 per cent in frequency and 20 per cent in severity from 1940. Steel foundries had the highest injury rates. The Aluminum Co. of America, Los Angeles, holds the best known all-time, no-injury record, 2,034,419 man-hours. The most important type of accident was getting hands and other members caught in or between moving ma-

chinery.

In the non-ferrous metals industry, the frequency rates rose 28 per cent from 1940; the severity rate upped 19 per cent. Smelters, as ever, were the industry's biggest problem. Workers were injured principally on machinery, particularly rolls and presses.

Critical Metals Are Reshuffled

WPB reshuffles the cards every so often, reclassifying basic materials into three groups, based on their plentifulness and critical status. A new deal took place about Aug. 21st, the fifth dealing of the cards, the previous having been July 6th.

The cards are stacked up in three piles: First are the materials, inadequate in quantity for war and most essential uses; second, sufficient for many essential needs; third, adequate for all appropriate types of present demands, including use as substitutes.

All steel and zinc now appear in Group I, as well as many grades of lumber. Also included are steel and rubber scrap. Silver continues in Group II, since it is commercially scarce, though large stocks exist. Group III is to be scanned closely as possible substitutes. They are largely mass products of coal mines, oil fields, quarries, forests, and fields, with few metals. Pig lead is perhaps the outstanding metal in this group, a fact which has elicited much comment and attempts to use it as a substitute.

In Group I the metals that are described as "most critical" are labeled with an asterisk. They are aluminum, brass, bronze, copper, magnesium, molybdenum, nickel and nickel alloy, tantalum, tin, tungsten, tungsten carbide and vanadium.

In Group II, 19 metals are listed, from antimony to zirconium. Three grades of iron are listed: Gray cast, malleable and pig.

In Group III are ferroboron, ferromanganese, gold, indium, lead, osmium, palladium and sodium.

Like a railroad timetable, these classifications are subject to change without notice. Harvey A. Anderson, Chief, Conservation and Substitution Branch, WPB, points out that changes may be due to sudden demand for the materials, to modification of government regulations, or to variations in the labor, manufacturing or transportation features that affect the supply.

Enemies Lack Copper—and How!

There is at least slight consolation in the fact that our enemies are probably more distressed by meagerness of return from salvage of copper than we are by our own deficiencies. Experiments have been made in Italy to recover copper from vine leaves sprayed with copper sulphate by burning them and extracting copper from the ashes. Five pounds per acre have been recovered. Much of this metal is of American origin. Again, it is evident that copper is the "everlasting metal."

In occupied France, a winegrower who needs copper sulphates for spraying must turn in an equivalent weight of copper metal. Vichy also offers a litre of wine in exchange for 200 grams (0.44 lbs.) of copper. Five hundred tons of copper was collected from statues removed from towns throughout the country.

The Dutch bury their copper kettles

and other kitchen copper-ware to keep it out of the hands of the Nazis. They secretly exhume it periodically to polish it so it will not deteriorate too rapidly. Letters from Holland to friends outside of the country frequently refer to "Mr. C. Kettle's funeral," or "The Kettle family is taking a long holiday."

Scrap, Increasingly Important Potential

Scrap stock piles of steel plants have shrunk 40 per cent in the past 18 months, as of July 1, according to the American Iron and Steel Institute. On Jan. 1, 1941 scrap in mills' storage yards totaled 3,934,000 tons, which had shrunk to 2,429,000 tons on July 1, 1942. In other words, instead of a six weeks' supply, as of 18 months before, mills had only two weeks' supply.

There is undoubtedly a very satisfactory reservoir in the country but it will take rigid organization to recover it. Thus, an interested citizen was picking blueberries on a farm at Pittsfield, N. H. and saw at least three tons of ferrous scrap rusting behind the barn. The aged farmer, working 16 hours a day, asked the citizen when he, the farmer, could find time to take it to collection points.

However, collecting of rural scrap has by no means been dormant. WPA men, scouring back roads of the farm country and extracting abandoned rails from city streets, have turned in 100,000 tons of metal. Since the drive for rural scrap began in April, 54,000 tons have been gathered through July by WPA crews.

Between last October and the end of June, 44,900 tons of steel rails were removed from streets. Farm machinery makers through their branch and sub-branch offices have been important collectors of country scrap.

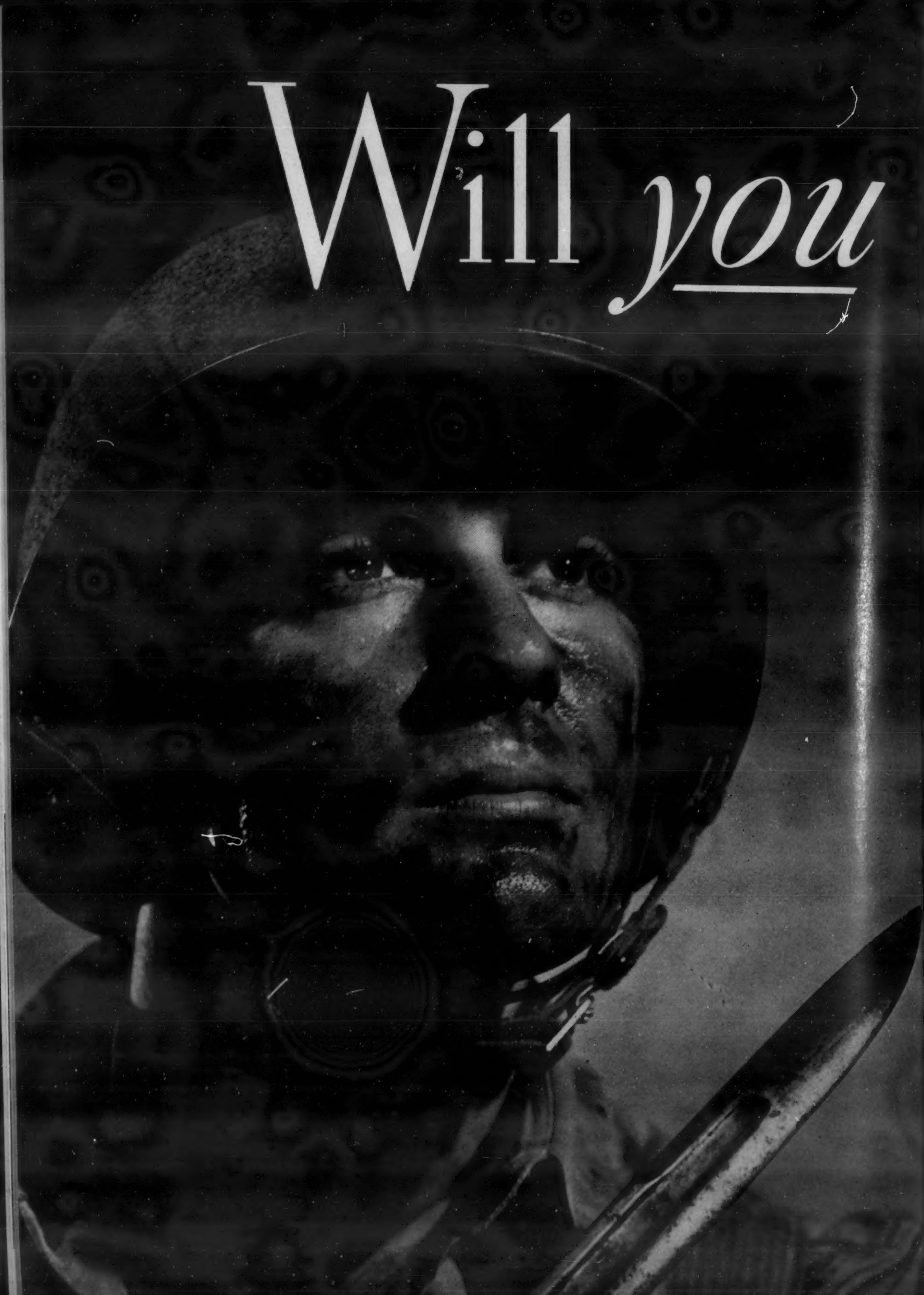
Over 40 tons of critical metal a month has been collected by tube-for-tube exchange over toilet goods counters, yet actual consumption of metals in tubes was 200 tons monthly during the first quarter of 1942.

The War Department has set up efficient salvage sections with our combat forces in the field. During the first World War, such departments returned to service more than 90 per cent of all salvaged equipment. After the Meuse-Argonne offensive, 4,272,969 articles were collected, these including American stoves and large German guns.

Novel methods of salvaging and interesting items have come to light. At Watertown, N. Y., two miles of river bottom was bared by erection of a temporary dam, thereby leading to recovery of an old iron bridge in the water since 1924, yielding 30 tons of scrap. Much miscellaneous metal was recovered from this river bed dumping ground, such as automobile bodies.

Walt Disney contributed two iron deer from his front yard, together weighing a ton, enough material to make one 75 mm. field piece or 10,100 incendiary bombs.

The historic "golden spike" stretch of track that joined the nation's first transcontinental railroad in 1869 was turned over to wreckers in late July. This stretch, between Corrine and Lucin, Utah, was superseded by a cutoff built three years ago. The golden spike was removed shortly after the ceremony of driving it, now reposing in a San Francisco vault.


Will you

Our Wartime Mistakes

By hindsight—and with the help of some welcome plain-speaking by a few honest but probably unpopular patriots—it becomes clear that in gearing our metal industries for war production we made several costly mistakes. We (and "we" were personally no exception, either) grossly underestimated our war needs for several metals, mired ourselves in a gooey priorities morass, tarried too long with much of our conversion, mishandled our sub-contracting, and failed to "balance" our production schedules and raw-material flow so that sub-assemblies and sub-components become available for incorporation in each war machine at about the rate needed.

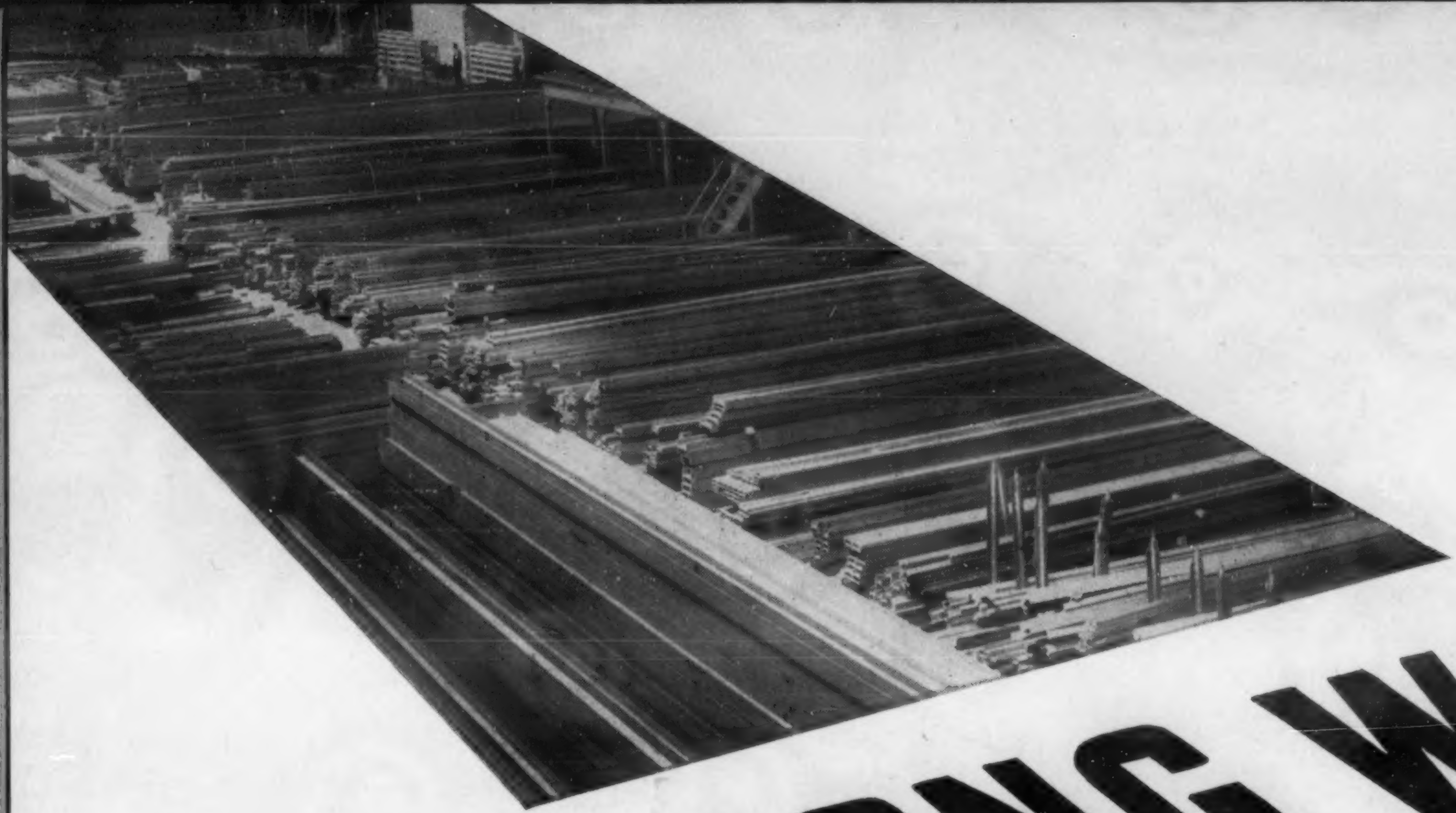
In certain processing fields—heat treatment particularly—the necessary delegation of jobs to inexperienced shops piled reject on reject, until the kinks were finally straightened out. The salvage effort was almost naive in some of its gropings. A combination of these and other errors has slowed-up our production rates for some types of armaments to points well *below* the goals established by the President.

But are we downhearted? Hell, no! Many of these mistakes have been or are being corrected. In fact, they seem now to be providing a terrific incentive to over-plan, and in some of the lines that are now below par the scrambling to boost production is certain to find them topping the quota by the year's end. Furthermore, every day we hear of the recent correction of some broad technical mis-practice that was putting a crimp in some major schedule.

And we can set against our fumbles a towering score of impressive achievements—statistical and technical—to lend assurance to the statement that a great job is being done. Steel cartridge cases, the development of the NE steels, the Liberty ship building achievements, the overall aircraft production results, the truly phenomenal accomplishment of the machine tool industry, much of the "conservation-through-substitutes" work, and the hundreds of successful local programs to swell production in the face of formidable obstacles—the fact of these should also be admissible evidence.

This is not to condone our blunders, which have cost us precious men, time and money. But we have stumbled in the way that a democratic people, faced with the most colossal organizing job in all history, must inevitably stumble in the absence of autocratic dictating. What we need is not less democracy but *more engineering*—and we herewith hail those dozens of applications of sound technology that have given us *something* to cheer about to date. Let's go on and use our better and more numerous engineers at least as well as the enemy uses his!

—F. P. P.



IT'S A LONG WAY...

from RAW STEEL *to the* BATTLE LINES!

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A Serious Rail Problem

"A railway is no better than its track. And in the track the most critical unit is the rail."

We quote from an editorial in the *Railway Age* for July 25 — "Rail—A Growing Problem." After calling attention to the fact that to date the track structure has given a most creditable account of itself, in carrying the heaviest traffic ever handled with a dependability never before attained, it states that a situation is developing that warrants most careful consideration.

A comparison is made between the gross tons of new rail laid in replacements per million gross ton-miles of freight handled (including locomotives and tenders) during the 10-year periods, 1922-1931 and 1932-1941. Only 0.79 ton per million gross ton-miles has been laid as replacements in the last decade, whereas for the previous 10 years the figure was 1.55 tons. And in 1942 this ratio will be lower still.

Undoubtedly this is a "cause for serious concern." The number of transverse fissures reached a new high last year but the use of the fissure detector car for finding bad rails, among those installed prior to the adoption of controlled cooling, has been a saving factor in preventing broken rails. This situation cannot safely go on this way.

We subscribe to the statement that these developments support the insistence of the railways for the rolling of a tonnage of rails commensurate with the wear and tear now occurring. Those in authority should give more consideration to rails than has thus far been apparent—rails are really a war measure. Conditions can develop under which the loss of lives and material might be a major disaster.

—E. F. C.

Steel Capacity is Up

A major metallurgical engineering achievement has been accomplished by the American steel industry during the first half of this year —628,350 net tons have been added to the country's steel ingot capacity. The total has now reached 89,198,320 tons. This is an increase of 9,012,682 tons over the 80,185,638 tons as of Jan. 1, 1938, or an expansion of about 11.25 per cent in 4½ years. The present total is probably 50 per cent of the entire steel capacity of the world, according to the calculations of the American Iron and Steel Institute.

A feature of the recent expansion is the addition to electric steel capacity of 488,380 tons bringing the total to 4,225,890 tons. This is 2¼ times the capacity of 1,882,630 tons available on Jan. 1, 1940. It is nearly 3 times the capacity available 8 years ago or on Jan. 1, 1934.

Bessemer steel capacity has not changed this year and the increase in open-hearth has been but 139,970 tons or about 22 per cent of the total expansion.

Attention is called to the fact that the present capacity of the steel industry is almost half again as large as the capacity at the close of World War I, and is one-third greater than the maximum tonnage of steel which the industry was called upon to produce in any year prior to 1941.

Expansion in pig iron capacity has not been neglected—this stood on July 1 at 60,836,480 tons, an increase of 442,500 tons in 6 months.

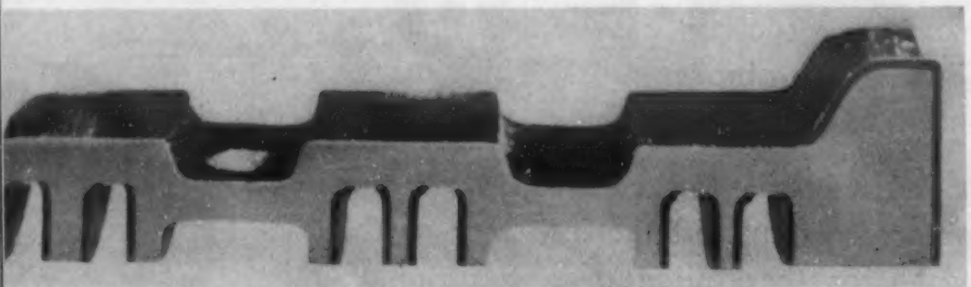
Operating as the industry has in the last year—under great pressure to turn out every ton possible—the record which has been made is one to be proud of.

—E. F. C.

(Editorials continued on page 448)

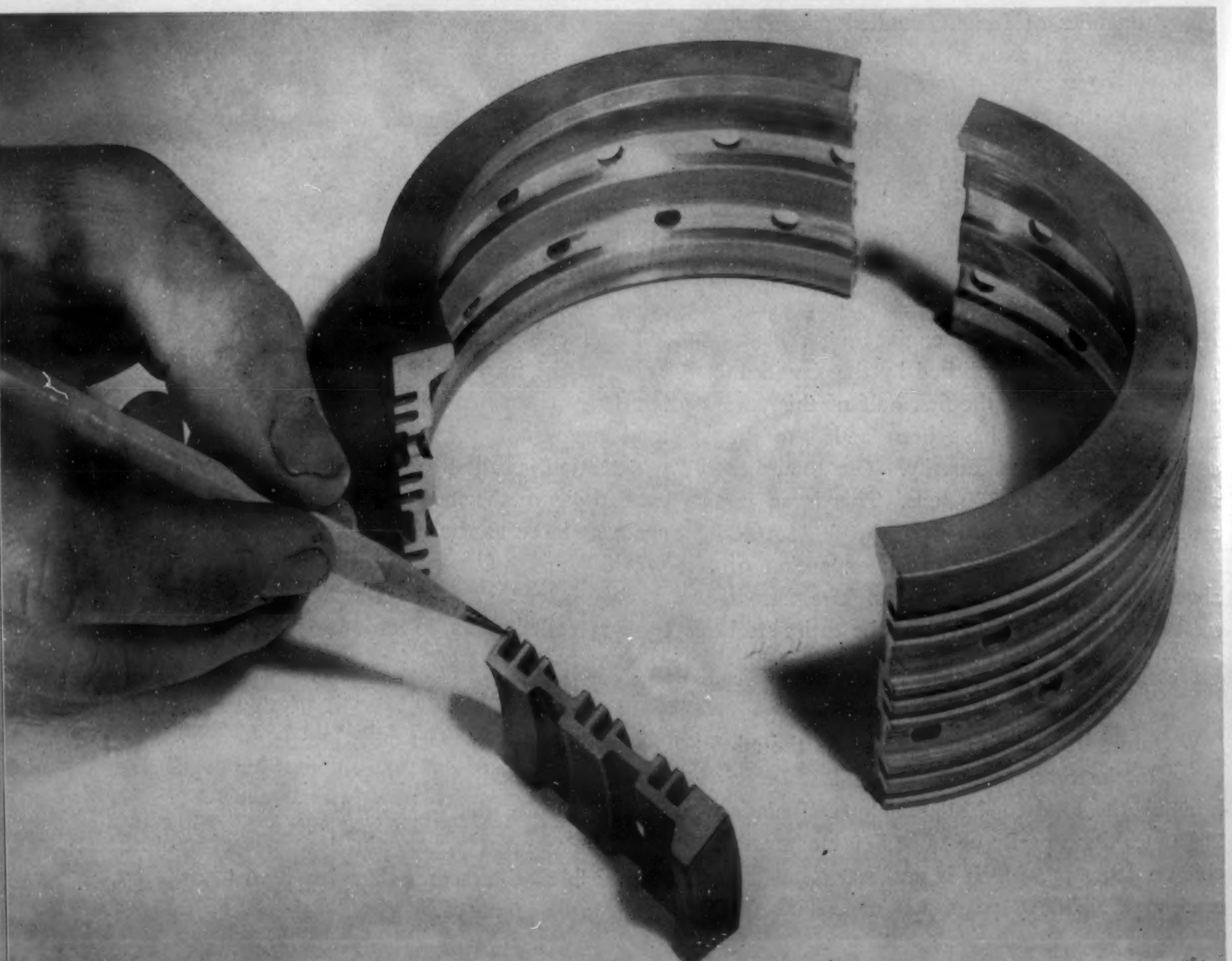
Nitriding an Aircraft Engine Part

The superlative wear-resisting properties of nitrided steel have led to many applications of the process in the manufacture of war equipment, and especially of certain aircraft parts. Information on nitriding practice and on the associated operations of normalizing, hardening and tempering, machining, etc. is therefore more than ever welcomed by engineers in the metal industries. This article describes all these, as applied in the production of a propeller shaft thrust bearing spacer.—The Editor.



by GERALD E. STEDMAN
Detroit, Mich.

A section of a propeller shaft thrust bearing spacer which has been cut, polished and etched to show the depth of the nitride case. It also shows the absence of case where surfaces were protected against nitride penetration.



THERE IS NO AIRCRAFT engine part more vital, nor any more subjected to strain, than the propeller shaft thrust bearing spacer. The practice of the N. A. Woodworth Co., Detroit, in nitriding this part is set forth below.

This spacer can roughly be described as a multi-slotted sleeve with an o.d. approximating 10 in., the production of which requires 54 separate operations. Its weight at the start is 18.25 lbs. and its finish weight is 1.187 lbs. It is made from AMS 6470, Nitralloy G, analyzing: Carbon 0.38-0.45, manganese 0.40-0.70, aluminum 0.95-1.35, chromium 1.40-1.80, molybdenum 0.30-0.45 per cent. The closed end surface and inside bearing radius are the wearing surfaces receiving nitriding.

Heat Treating and Machining

The spacer comes first to the heat-treating department as a rough forging. It is carefully inspected, normalized at 1800 deg. F. and cooled in air to make sure that all forging strain is removed. It is then hardened in an open, gas-fired furnace at between 1700 and 1750 deg. F., soaked until uniform and quenched in oil. The operation stays at the high side of the heat range to assure that all free ferrite is eliminated, making the job easier to machine.

The spacer is then drawn to machine range in a forced circulation tempering furnace, approximating 1180 deg. F. for 3 hrs. to produce a Brinell reading of 290 to 302. This treatment gives a uniformly sorbitic structure, easy to machine and, likewise, the necessary physical qualities. It is then sent through a rotoblast to remove all scale.

Then the spacer receives a series of machining operations, of which only enough will be mentioned to indicate the tremendous detailing this part receives. After a sequence of machinings . . . disc grind end, turn bore, turn o.d., bore, face . . . the spacer is checked 100 per cent for hardness and to see that all forging scale and bark is absent. Then occurs another sequence . . . two turns, bore i.d.'s, face, centerless grind, carboloy bore and face to provide nice finish and hold to accurate size, blanchard grind, turn ring slots on o.d., remove burr from o.d., bore inside grooves, polish inside grooves, drill and ream 32 holes, burr all previous operations 100 per cent. The part is then given another exhaustive inspection before tinplating.

Stop-Off Tinplating

The spacer is tinplated in an alkali bath to obtain an 0.0002 to 0.0003 deposit. Tin electrolytes have great throwing power, easily cover inside surfaces, have good adherence to the base metal, and provide the best protection against nitriding of those areas that are to stay soft, or should not be exposed to nitriding and the ensuing nitride growth.

The sixth general operational sequence in production of this spacer is a series of operations to remove the tinplate from the surfaces to be case hardened by the nitriding process. The tin is ground from the closed end and the slots are regrooved to remove the tin. The slot side is hard and the bottom soft, so it is necessary to grind from an end angle. A photograph of a cross section illustrates this case hardening technique of tin protection. It is necessary to break the i.d.'s because sharp corners chip in nitriding. This is caused by nitriding growth so that sharp corners build out and break off as they cool. This must be prevented by breaking the corners. Precision methods on the closed end and inside wearing radius of this spacer, permit nitriding growth to be premeditated and compensated for.

A slight growth takes place during any nitriding process. Allowance for this growth can be made sometimes in the final machining or grinding operation before nitriding or by lapping or by other suitable means after nitriding. The exceptionally close tolerances, the relativity of surface dish and side slot dimensional effects plus the inside angle tangent to the radius providing a 95 per cent bearing face which in assembly is fitted to a ball race—all added to the problem of determining the allowances for nitride growth in order to produce consistently a perfectly flat and parallel end face and a correctly dimensioned side slot after nitriding.

The closed end of the spacer is concave dished three degrees. After nitriding, this concave surface because of the nitriding growth becomes a perfectly flat plane. But this growth recovery affects the side slot so that an oversize allowance of 0.003 is made, then, after nitriding, this slot closes in, allowing the right amount of stock for finish size. The ring grooves (or slot) are 0.095 before nitriding and close up to 0.092 after nitriding.

Loading the Nitriding Furnace

The propeller shaft thrust bearing spacers are packed in a nitriding furnace, the end face to be nitrided, up. The load carries 120 to 130 pieces, packed in layers with a separating wire screen protected by special paint. Due to the large i.d. of the spacer, other smaller parts can be packed in to conserve space. None are permitted to touch the tinplate. The nickel-chromium pots into which the parts are packed are 22 in. in diameter, 28 in. deep.

A slight oil film is left on the parts when packed to prevent the tinplate from running. The tin is fluid at nitriding temperatures. But, with the oil film on, it maintains its previous surface tension and is kept from creeping. By the time the oil has burned off, the surface has begun to be attacked by the ammonia and the tin does not creep.

Tin effectively prevents nitriding. However, since

A nitriding furnace with a load of propeller shaft thrust bearing spacers for a 50-hr. cycle. The large basket shown is 28 in. in diameter and 48 in. deep.

ammonia is slightly soluble in tin, tapped holes or similar areas, requiring a very light cut after nitriding, occasionally may show a hard skin.

The parts are stacked with the large diameter downward, further preventing the tendency of tin to creep. Surfaces for tinplating need not be nearly so smooth as those for copper plating, as used in selective carburizing, in that the tin is fluid at the temperatures it does its work and fills up pores for all commercial purposes better even than nickel.

The Nitriding Operation

The nickel-chromium pot is loaded into the furnace, the ammonia inlet is turned on, the fan at the furnace bottom is turned on and the furnace is run until an ammonia dissociation of 10 per cent is achieved. The heat is then turned on and the furnace is held at 975 deg. F. for 50 hrs. The heat is then cut off and the furnace cooled down. The ammonia flow is slightly increased to prevent air being sucked into the furnace pot and discolor the load. Discoloration can be caused by the contraction of the gases and is noticeable in that it produces a rainbow of colors on the steel parts' surfaces which in no manner effects the hardness but doesn't look well. The load is then allowed to cool down below 250 deg. F. before removing. This requires from 5 to 10 hrs., depending upon the load. The fan continues to run during the cooling time.

The nitriding furnace is built with a fan at the bottom. The fan operates in clockwise revolutions until the furnace has reached 600 deg. F. After that, it automatically reverses itself, clock and counterclockwise, once each minute with a quarter minute coasting between. When the fan sucks ammonia down through the load, the ammonia is automatically fed into the top inlet. During the reverse cycle, the ammonia feeds through the bottom.

This constant and uniformly controlled flow of gas through the load guarantees a uniformity of not over 0.002 variation in case depth throughout the load. It also permits running the full load just over the minimum in that if case depth is achieved in one spot, there is absolute assurance it will be accomplished in all spots of the load. Nitriding is achieved in 55 to 60 hrs. when other practices require 90 hrs. to achieve the same case depth. The case requirement is 0.017 to 0.022; 0.020 to 0.022 case depth is consistently obtained.

Only the ammonia that breaks down on the surface of the steel is effective in nitriding. Therefore a considerable saving can be effected by preventing the breakdown of the ammonia on any of the alloy furnace parts such as hinges, baskets, etc. This is effectively accomplished by cleaning all the alloy parts and spraying with a mixture of chromium oxide and sodium silicate. This coating lasts for several loads, is impervious to ammonia and can be sprayed on like paint with a spray gun. Necessary to explosive manufacture and other chemical war purposes, ammonia is scarce and the current price is around 16 cents per lb.

Case Depth and Hardness

A nitriding case depth of 0.011 to 0.015 is obtained during the first 25 hrs. of heat and, at the end of the second 25 hrs., a case depth of 0.20 to 0.022 materializes. In other words, the rate of depth decreases to one-third the speed in the second 25 hrs. as is evidenced by the comparison between 0.015 and 0.020, an addition of but 0.005 during the latter period. There is ample premise to conclude that the catalysts become poisoned after a certain amount of use and that, in a way, this poisoning can be neutralized by a slight temperature step-up. For instance, there is some evidence that greater case depth can be gained within a given time by starting temperatures at 940 deg. F. and stepping up in rhythms of 10 deg. periodically, rather than firing from the start at 990 deg.

After nitriding, the spacer wearing surface should Rockwell 15 N 92 minimum. All operations on the part after nitriding are grinding, the tin being left on the parts not ground.

Tests used during this series of operations are: (1) Drop test for tin plate thickness, (2) Brinell test for core hardness at the first heat treating, (3) superficial Rockwell to check case hardness, (4) polish and etch sample, using the Brinell to measure case depth.

All furnace parts such as hinges, baskets, etc., are sprayed with a protective coating to prevent ammonia breakdown of alloy during nitriding processing at the Woodworth plant. This coating lasts for several loads and, like paint, can be sprayed on.

The Properties of Pure Nickel—I

BY E. M. WISE and R. H. SCHAEFER

Staff Advisor and Metallurgist, respectively Research Laboratory, International Nickel Co., Bayonne, N. J. [Present addresses, International Nickel Co., 67 Wall St., New York and Amer. Manganese Steel Co., Chicago Heights, Ill., respectively]

The uses of pure nickel in the radio, chemical, food-processing and other industries depend heavily on certain special property-values of the material, which vary markedly with relatively slight changes in purity. This three-part article is a comprehensive compilation of the physical, mechanical, electrical and other properties and constants of (1) very pure nickel and (2) commercial wrought "A" nickel and (3) a discussion of the effects of some alloy additions on the properties of low-carbon nickel alloys made from commercial electrolytic nickel treated to produce a sound, workable ingot. —*The Editors*

NICKEL SALTS OF HIGH PURITY can be prepared in small quantities by straightforward chemical methods, and metallic nickel can be produced from the salt by reducing the oxide with hydrogen or by electrolysis. Quite pure nickel can also be produced by forming and subsequently decomposing nickel carbonyl, although contamination by traces of carbon or oxygen is difficult to avoid. Contamination from the crucible has been a source of much difficulty in melting pure nickel in hydrogen or *in vacuo,* although recent developments in sintered alumina crucibles may eliminate this difficulty. To avoid this complication nickel may be electrodeposited in suitable form for subsequent rolling or drawing, or the pure powder may be pressed and sintered in hydrogen, which has the added advantage of removing traces of carbon or oxygen which are apt to be present in powdered material. Blistering is difficult to avoid in sintered material and, to a lesser extent, in the electrodeposited samples.

In view of the factors mentioned above, electrodeposition from a very pure nickel chloride electrolyte using insoluble iridium platinum anodes seemed to be the most satisfactory method for producing nickel of academic purity, and this was done by W. A. Wesley of our laboratories, yielding a product containing 99.99 per cent nickel and containing only 0.0008 Cu, 0.0005 Fe, 0.0003 Co and 0.0025 per cent C. Details of this procedure will be described in the near future.

Types of Nickel

In the data presented below, the properties determined by numerous investigators on samples of nickel of high but not necessarily of identical purity are summarized. In selecting these data, the experimental method as well as the purity of the nickel, were considered. It should be recognized that the electrical resistivity and particularly the temperature coefficient of electrical resistivity are very sensitive to impurities in solid solution and are good criteria of purity, which is not true of the Curie temperature due to the fact that this temperature is increased by iron and cobalt and lowered by other impurities so that the net effect of copresent impurities may be zero even when considerable amounts of impurities are present.

The following classifications covering the types of "pure" metal were made, and materials used for determining each of the constants are keyed to this list:

(a) High purity electrolytic nickel prepared in the Inco laboratories by electrodeposition and containing 99.99 per cent Ni.

(b) High purity Hilger nickel containing 99.971 per cent Ni, 0.018 Fe, and 0.01 C. Some of the latter element may have been lost in working into wire.

(c) High purity electrolytic nickel deposited from an ammoniacal bath and subsequently vacuum melted. This contained 99.94 Ni; 0.016 Co; 0.03 Fe; 0.006 Cu; 0.006 Si; 0.005 C; 0.004 per cent S.

(d) High purity carbonyl nickel powder or granules sintered in hydrogen or vacuum melted.

(e) High purity carbonyl nickel, directly deposited.

With few exceptions, which are noted, the properties relate to well annealed material.

Physical Constants

The physical constants of pure nickel are:

Atomic number.....	28
Atomic weight	58.69
Weights of isotopes.	58, 60, 61, 62 [30]
Freezing point......	1455 deg. C. (c) [1]
Crystal form—face centered cubic (close packed hexagonal form has been reported for some films)	
Lattice constant....	3.5168A° at 24.8° C. (a) [2]
For close packed hexagonal—	a = 2.49A° [30]
	c = 4.08A° [30]
Density (computed)*	8.908 gm. cm.$^{-3}$ at 20° C. (a)
Density cast........	8.907 gm. cm.$^{-3}$ at 23° C. (c) [3]
Density worked and annealed	8.901-8.903 gm. cm.$^{-3}$ at 25° C. (c) [3]
Latent heat of fusion	73 cal. gm.[7]
Vapor pressure.....	1.2 $\times$ 10^{-6} mm. Hg at 1000 deg. C.[8]
	9.4 $\times$ 10^{-3} mm. Hg at 1455 deg. C.[8]
	2.3 mm. Hg at 2000 deg. C.[9]
Boiling point approx.	3380 deg.. C.
Emissivity (monochromatic 0.65μ) for brightness match optical pyrometry..	0.355 [14]
Emissivity (total)...	0.19 at 1000 deg. C.[15]
Reflectivity (yellow green)	0.64 at .550μ (c) [3]
(ultra violet).....	0.413 at .300μ (c) [3]
Reflectivity heat (infra red)	0.835 at 2μ [16]
	0.870 at 3μ [16]
Thermal E. M. F. vs.	Pt 1.485 $\times$ 10^{-3} volts 0-100° C. (b) [3]

* This density computed from lattice constant and a value of 6.06 $\times$ 10^{23} for Avagadros number and the atomic weight.

Thermal Properties

The thermal properties of pure nickel are as follows:

Average Coefficient of Linear Thermal Expansion (see Fig. 1)

10.22 $\times$ 10^{-6}/deg. C —180 to 0 deg. C.[4] (a)
13.3 $\times$ 10^{-6}/deg. C. 0 to 100 deg. C.[4] (a)
14.63 $\times$ 10^{-6}/deg. C. 0 to 300 deg. C.[4] (a)
15.45 $\times$ 10^{-6}/deg. C. 0 to 500 deg. C.[4] (a)
13.3 $\times$ 10^{-6}/deg. C. 25 to 100 deg. C.[3] (c)
14.4 $\times$ 10^{-6}/deg. C. 25 to 300 deg. C.[3] (c)
15.5 $\times$ 10^{-6}/deg. C. 25 to 600 deg. C.[3] (c)
16.3 $\times$ 10^{-6}/deg. C. 25 to 900 deg. C.[3] (c)

True Coefficient of Linear Thermal Expansion[8] (see Fig. 1)

12.5 $\times$ 10^{-6} at 20 deg. C.[26] (d)
13.5 $\times$ 10^{-6} at 100 deg. C.[26] (d)
14.5 $\times$ 10^{-6} at 200 deg. C.[26] (d)
16.3 $\times$ 10^{-6} at 300 deg. C.[26] (d)
16.3 $\times$ 10^{-6} at 400 deg. C.[26] (d)

Thermal Conductivity:

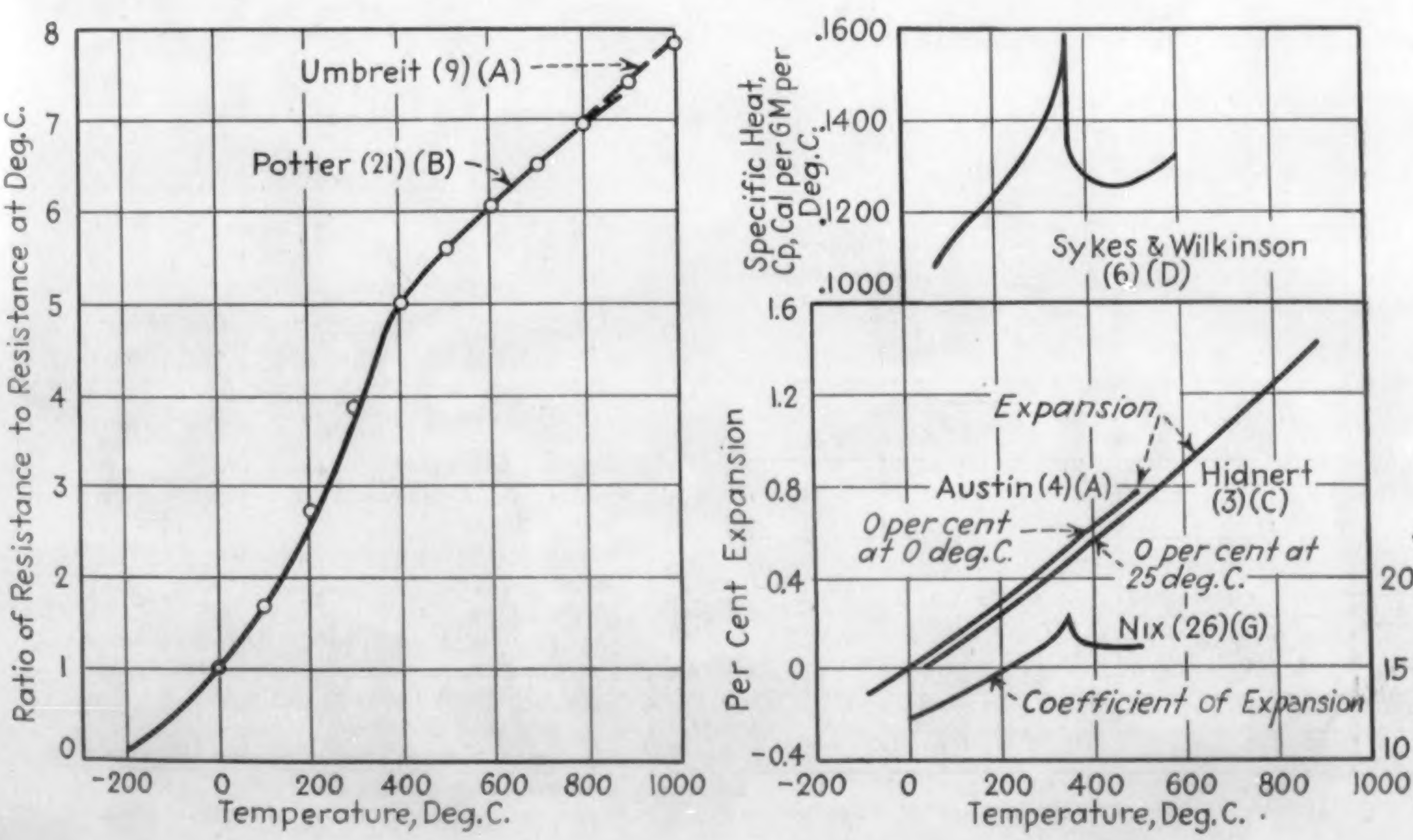
0.198 cal cm.$^{-2}$ sec.$^{-1}$/deg. C. cm.$^{-1}$ at 100 deg. C. (c) [5]
0.175 cal cm.$^{-2}$ sec.$^{-1}$/deg. C. cm.$^{-1}$ at 200 deg. C. (c) [5]
0.152 cal cm.$^{-2}$ sec.$^{-1}$/deg. C. cm^{-1} at 300 deg. C. (c) [5]
0.142 cal cm.$^{-2}$ sec.$^{-1}$/deg. C. cm^{-1} at 400 deg. C. (c) [5]
0.148 cal cm.$^{-2}$ sec.$^{-1}$/deg. C. cm^{-1} at 500 deg. C. (c) [5]

Specific Heat (see Fig. 1):

0.1123 cal. gm.$^{-1}$ deg. C.$^{-1}$ at 100 deg. C. (d) [6]
0.1225 cal. gm.$^{-1}$ deg. C.$^{-1}$ at 300 deg. C. (d) [6]
0.1367 cal. gm.$^{-1}$ deg. C.$^{-1}$ at 300 deg. C. (d) [6]
0.1267 cal. gm.$^{-1}$ deg. C.$^{-1}$ at 400 deg. C. (d) [6]
0.1265 cal. gm.$^{-1}$ deg. C.$^{-1}$ at 500 deg. C. (d) [6]
0.1326 cal. gm.$^{-1}$ deg. C.$^{-1}$ at 600 deg. C. (d) [6]

These values for specific heat are the average of 2 samples of cobalt-free nickel of high purity and were reported by C. Sykes and H. Wilkinson. For comparison with earlier values obtained by other methods, their report should be consulted.

Fig. 1 Variation of electrical resistance, specific heat and thermal expansion of nickel with temperature.



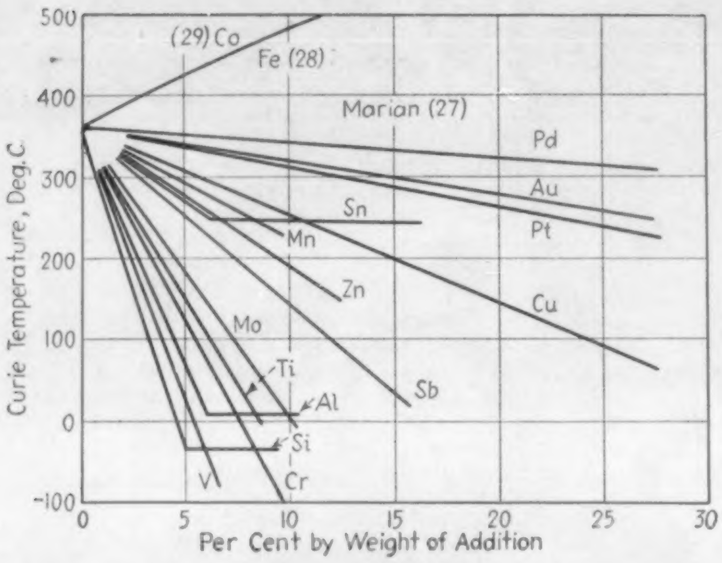


Fig. 2. The effect of specific single alloying additions on the Curie point of nickel.

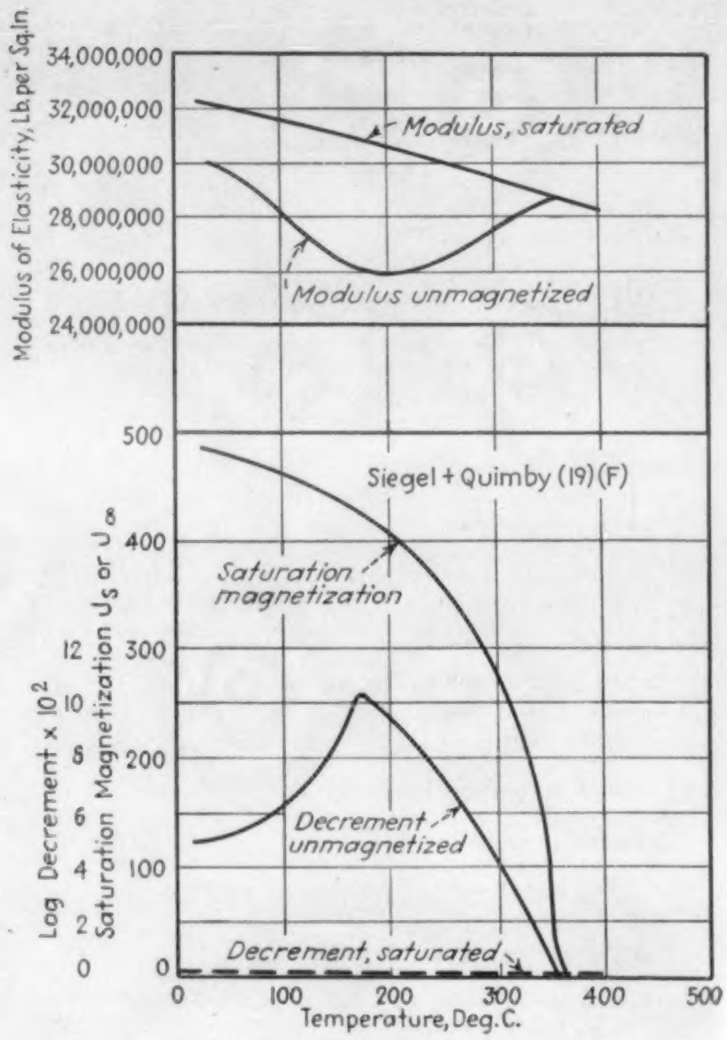
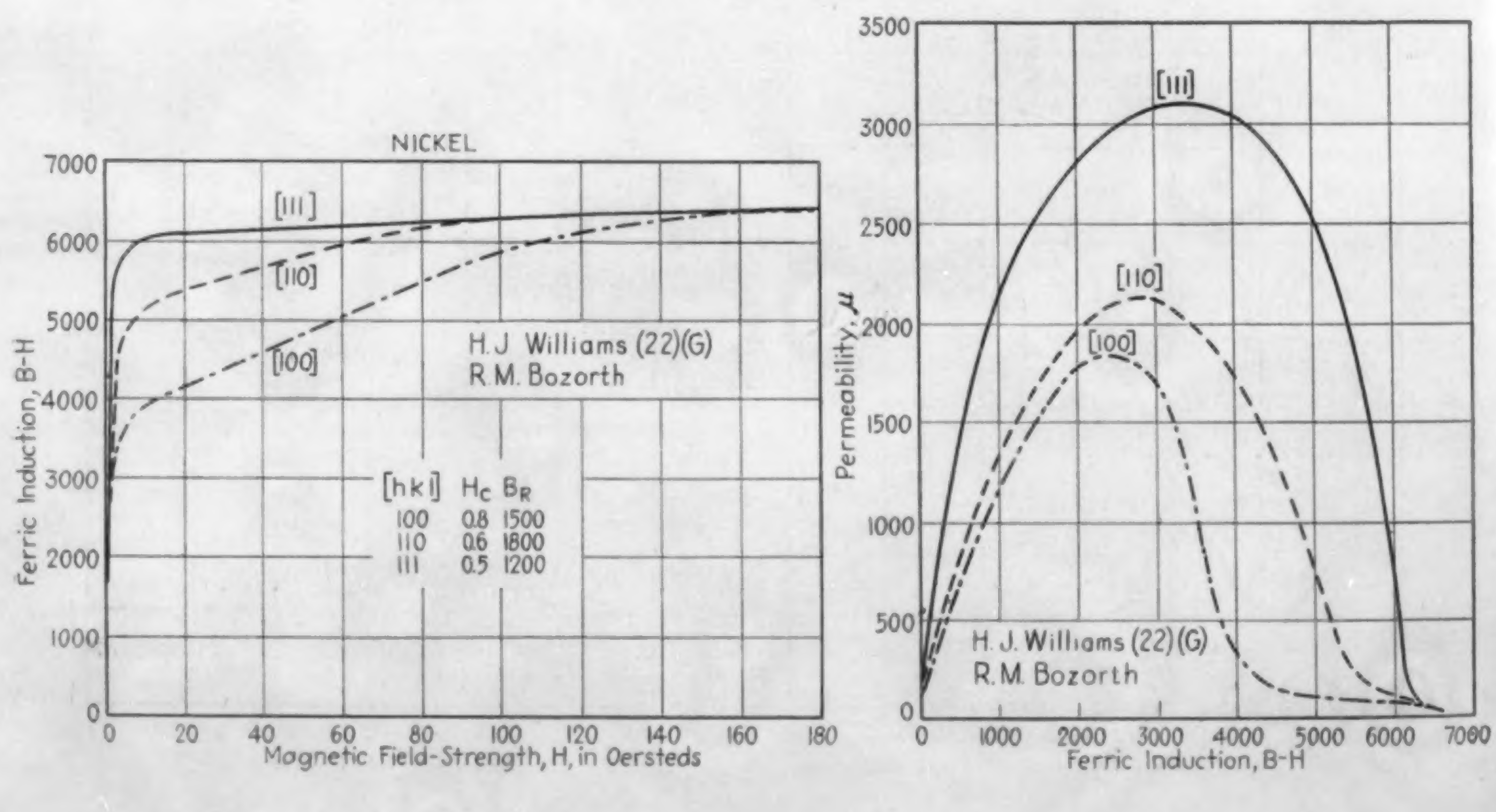


Fig. 3. Modulus of elasticity (top) and intensity of magnetization (bottom) of nickel at various temperatures.

Fig. 4. Magnetic induction and permeability values for high purity (single-crystal) nickel.



Electrical Properties

The electrical properties of pure nickel are:

Electrical resistivity:

6.141 microhm cm. at 0 deg. C. (a) [9]
6.844 microhm cm. at 20 deg. C. (a) [9]

Temperature coefficient of electrical resistivity:

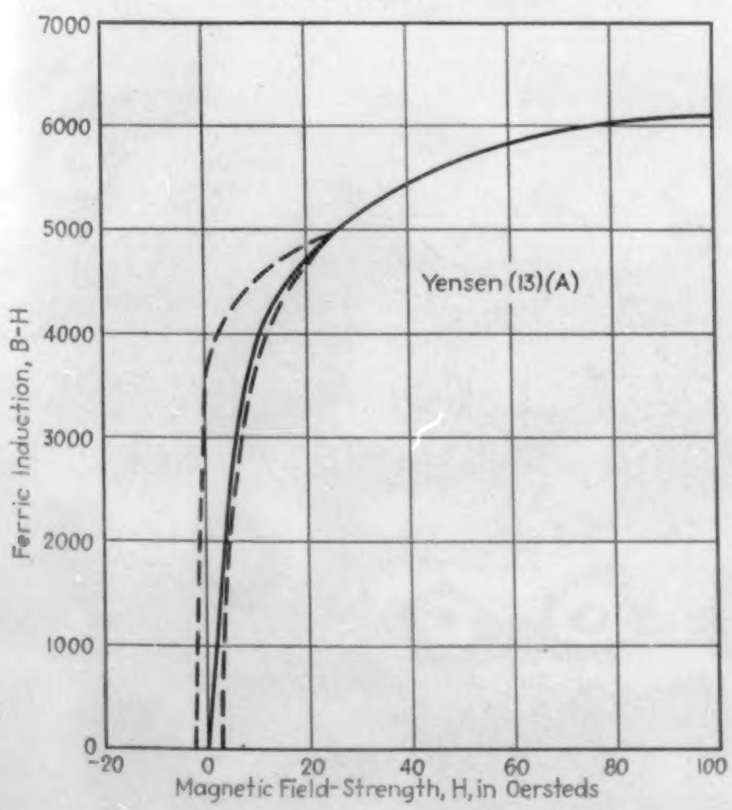
		Deg C.
0.00658	deg. $C.^{-1}$	0-100 (d) [25]
0.0067	deg. $C.^{-1}$	0-100 (c) [8]
0.00682	deg. $C.^{-1}$	0-100 (a) [9]
0.00692	(after vacuum firing) deg. $C.^{-1}$	0-100 (a) [9]
0.00681	deg. $C.^{-1}$	0-100 (b) [21]
0.00667	deg. $C.^{-1}$	0-100 (e) [11]
0.00706	(after vacuum firing) deg. $C.^{-1}$	0-100 (e) [11]

The last two values relate to material deposited on a substrate and may not be typical of randomly oriented polycrystalline material.

Resistance at other temperatures in comparison with the resistance at 0° C. is based on the determinations of Umbreit[9] and Potter.[21] The former's determinations are based on material (a), the latter's on material (b), but samples of (a) were also tested by Potter with good agreement. The resistivities given below were calculated on the basis of R_o = 6.141 microhm cm. See Fig. 1.

$\frac{R_t}{R_o}$	$R_t 10^{-6}$ ohm cm.		Deg. C.
0.08	0.49	"	at —200 (b) [21]
0.46	2.82	"	at —100 (b) [21]
1.000	6.141	"	at 0 (b) [21]
1.681	10.3	"	at +100 (b) [21]
2.57	15.8	"	at 200 (b) [21]
3.75	23.0	"	at 300 (b) [21]
4.99	30.6	"	at 400 (b) [21]
5.57	34.2	"	at 500 (b) [21]
6.06	37.2	"	at 600 (b) [21]
6.50	39.9	"	at 700 (b) [21]
6.97	42.8	"	at 800 (a) [9]
7.41	45.5	"	at 900 (a) [9]
7.86	48.3	"	at 1000 (a) [9]

Fig. 5. Magnetic induction of very pure polycrystalline nickel.



Magnetic Properties

The magnetic properties of pure nickel are:

Curie temperature, approx. 353 deg. C. (For effect of alloy additions see Fig. 2.)

Magnetic saturation value (B-H)∝, 6,500 estimated from Fig. 4; 6,150 was obtained by earlier workers. (a) [13, 3]

Intensity of magnetization $\frac{(B\text{-}H)}{(4\pi)}$ (for H = 200-300 oersteds) at various temperatures, as determined by Siegel and Quimby is shown in Fig. 3.[19] (Commercial cobalt-free annealed nickel.)

Magnetic induction and permeability of single crystal nickel made by melting very pure nickel powder (d) in extremely pure hydrogen based on very recent determinations by R. M. Bozorth and H. J. Williams[22] are shown in Fig. 4.

The maximum permeabilities observed in these tests are noted below.

μ [111]		3,090 (d) [22]
μ [110]		2,100 (d) [22]
μ [100]		1,820 (d) [22]
Hysteresis	H_c	B_r
[100]	0.8	1,500 (d) [22]
[110]	0.6	1,800 (d) [22]
[111]	0.5	1,200 (d) [22]

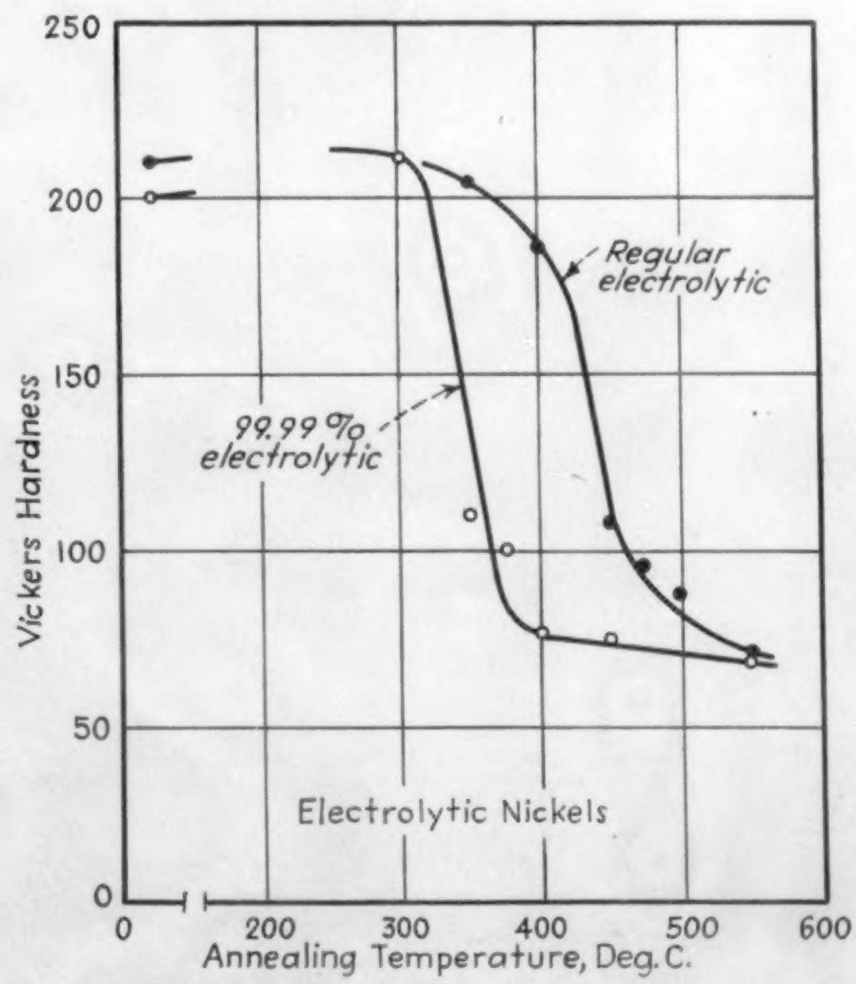
Magnetic induction of polycrystalline high purity nickel based on the determinations of T. D. Yensen[13] (a) is shown in Fig. 5 which includes a portion of an hysteresis loop from B 5,000.

The coercive force (H_c) (from B = 5000) was 2.73 oersteds.

Magnetostriction of polycrystalline nickel at saturation, extrapolated from Schulze,[30] is -32×10^{-6} Δ 1/1.

Values for the saturation magnetostriction of single crystal material presented by Marsh[28] from the data of Lichtenberger[34] are -24×10^{-6} [111]
-30×10^{-6} [110]
-45×10^{-6} [100]

Fig. 6. Effect of annealing on the hardness of two types of electrolytic nickel.



Mechanical Properties

The annealing temperature is sensitive to a large number of factors; reference should be made to Fetz's work in this connection.[10] Two recrystallization curves have been determined for very pure[17] (a) and regular electrolytic nickel, hydrogen annealed, cold rolled 50 per cent[17] and annealed one hour at temperature and are shown in Fig. 6. The temperatures at which recrystallization is complete are estimated to be 370° and 470° C. respectively. It should be understood that these values only apply to materials of the degree of purity indicated and the per cent reduction and annealing time used.

Tensile Strength (annealed) ....46,000 p.s.i. (a)[17] (c)[2]
Yield Strength 0.2 offset (annealed) 8,500 p.s.i. (a)[37]

Young's modulus at various temperatures and effect of magnetic field thereon, (annealed commercial cobalt-free nickel) as determined by Siegel and Quimby[19] are shown in Fig. 3.

Damping (logarithmic decrement) of the same annealed nickel at various temperatures and effect of magnetization thereon is shown in Fig. 3.[91] These samples contained Si 0.01; Cu 0.02; Fe 0.11; Mn 0.0; C 0.049; Mg 0.11, and S 0.05 per cent.

(To be continued)

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A Few Chuckles

Non-Porous Products!

From *Business Week*, July 4, 1942, page 5:

Among the enterprises identified as essential by the War Manpower Commission is "steel and non-porous foundry products."—H. W. G.

Carving Sets of Gold or Silver!

Information Digest, Office of Government Reports, June 29, 1942:

WPB orders that "after June 30, carving knives, forks and sharpening steels in carving sets may be made only of gold or silver."

Should the knife be silver and the sharpening steel gold, or vice versa?—H. W. G.

Task for Metallurgists!

Chosen men of this war, or not, the metallurgists seem to be getting a great kick out of the big job that has been handed to them, grin gleefully over the revised values that make silver a substitute for tin.

"Get rid of the idea that tin is a cheap, base, ordinary metal," one of them advised. "As a matter of fact, tin comes pretty close to being a noble metal, if it isn't actually one."

Look up the adjective noble, as applied to metals. You'll find gold, silver and platinum listed as "noble" metals, with this addition: Any metal or alloy relatively superior in certain properties, especially *resistance* to corrosion or *fusibility*. *Well, that's tin, all over.*

A Reader of "M & A"

Lynn, Mass.

Magnesium Alloys—Cast and Fabricated

—A Pictorial Presentation

Through the courtesy of the Aluminum Co. of America, we present a pictorial article on some of the operations—casting, rolling and extruding—in the production of various alloys of magnesium.

Magnesium's place today among the commercial structural metals has been achieved largely through alloy development. Alloying has made the metal amenable to heat treatment resulting in a product of increased strength; it has led to an improvement in other physical properties, fabrication characteristics, and resistance to corrosion. As a result the lightness of the metal is available for a multitude of applications in war products, particularly aircraft.

Of the alloying elements found in magnesium base alloys, aluminum is one of the most important. In all but a few alloys it constitutes from 3 to 12 per cent of the composition. Zinc also plays an important role and manganese improves the metal's resistance to corrosion.

Pouring ingots of special magnesium alloy. Sulphur is dusted on the molten metal to prevent oxidation by creating an inert atmosphere over the surface of the metal. During melting, salt flux is added which prevents oxidation by covering the surface of the metal with a thin layer of molten flux. By stirring the flux through the charge, it refines the metal and cleanses it of non-metallic impurities. The flux attains a consistency which makes it manageable during pouring, thus preventing flux inclusions in the casting.

Magnesium to be poured into castings is super-heated to several hundred degrees above its melting temperature. Pure magnesium melts at 1205 deg. F. Super-heating contributes to grain refinement. Before being poured into a mold, the metal is cooled to a pouring temperature which is carefully selected for each casting. Three to four times as much metal must be poured to produce a casting as is needed for the casting itself.

The casting is being poured and at the same time sulphur is being sprinkled on the flowing metal to prevent burning. Since magnesium reacts with water, an inhibitor is added to the molding sand, making the use of green sand molds possible. The inhibitor, made of such materials as sulphur, boric acid, ethylene glycol, ammonium fluoride, or combinations of these, produces an inert atmosphere in the mold cavity to protect the metal against oxidation.

The gates and risers of this airplane landing wheel are being removed with a band saw. The machinability of magnesium excels that of all other metals.

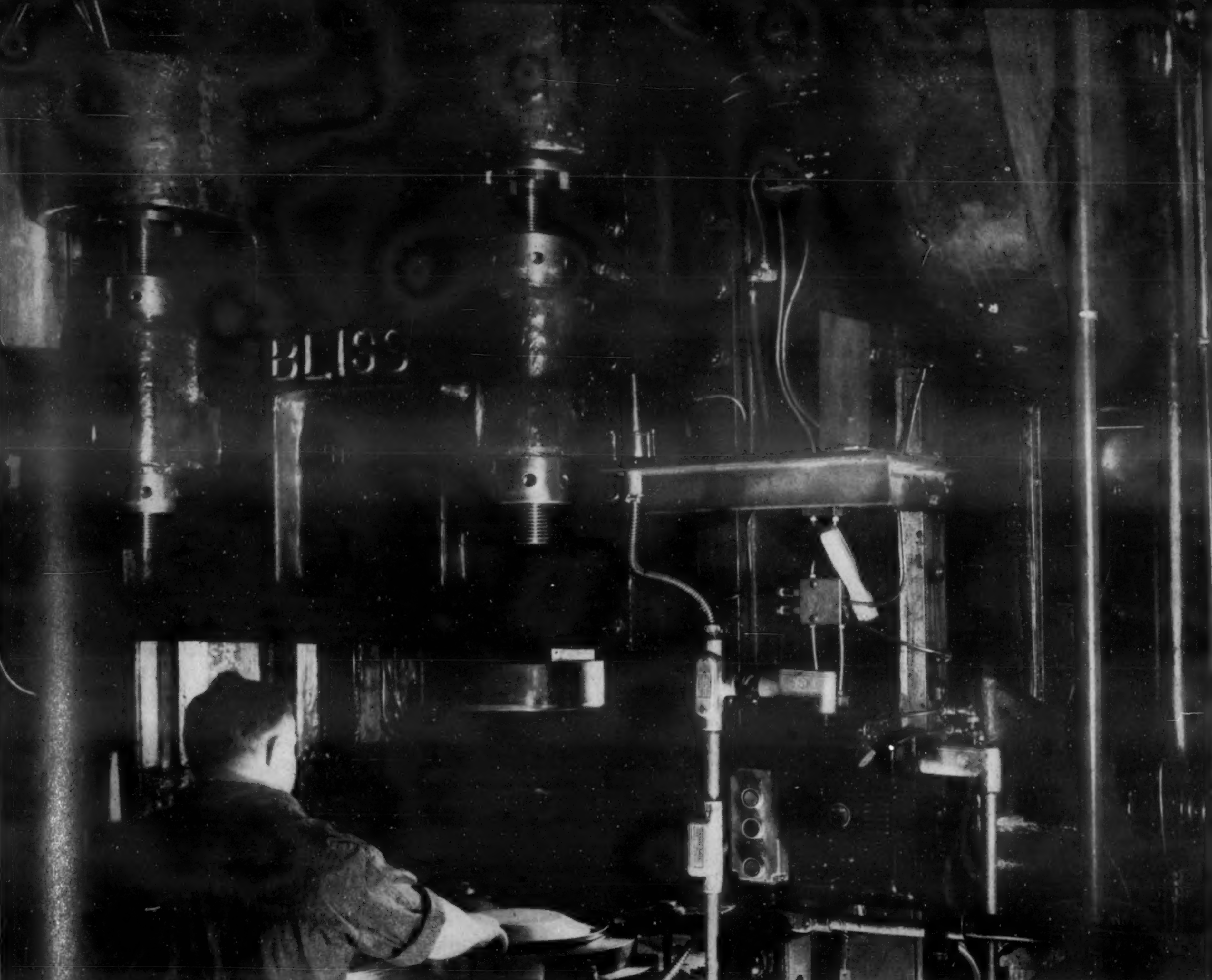
*Fins, and the remains of gates and risers are removed from these **air-cooled aircraft** engine sections with pneumatic chisels. Again the excellent machinability of magnesium asserts itself, as it does in the production of nearly all kinds of magnesium products.*

Finish trimming of an aircraft engine section is being done with an abrasive wheel. Rotary files are also used for this work. The grinding cabinet has a non-sparking aluminum table through which the grindings are exhausted and precipitated in a liquid.

The aircraft engine crankcase section has just been removed from the dichromate solution and will be rinsed in cold water, followed by a final rinse in hot water. Practically all magnesium parts receive this shop treatment. It retards or prevents tarnishing during succeeding operations, shipment, or in applications not involving corrosive conditions. For protection against salt water and moisture at least two finish paint applications over a primer (such as zinc chromate) are recommended. Several other chemical coatings (such as AMC Treatment G) having greater resistance to corrosion and which form a better base for paint than the dichromate usually are applied after machining and finishing and prior to painting.

This load of aircraft engine castings is ready for heat treatment. Most magnesium castings are heat treated, receiving both the solution heat treatment and the precipitation or aging heat treatment. It is during heat treatment that the alloying elements, aluminum and zinc, perform their tasks. The change of solubility of aluminum and zinc in magnesium is the basic principle behind heat treatment, and the resulting improvement of tensile strength and other physical properties.

The last rolling passes in the production of magnesium sheet are done cold to increase ductility and strength and improve the finish. The finished sheet is in the hard "as rolled" condition and, for additional fabricating operations such forming or drawing is often annealed. In the production of sheet the large reductions in the initial rolling from ingot to sheet are done hot. The rolling temperature is in the neighborhood of 700 deg. F., with a fairly large range.



Magnesium airplane wheel covers are receiving the second cold draw in their production from magnesium sheet. For deeper draws or more complicated forming operations, the sheet is heated to about 600 deg. F.

A strong weld is being made in this magnesium airplane oil tank with an oxy-acetylene flame using a special flux. The baffle sheets within the tank are joined to the tank shell by spot welds which make a strong joint. Both types of welds are used extensively in joining sheet structures. Note the cast fittings which have been torch welded to the tank.

Magnesium lends itself well to the extrusion method of producing bar, structural shapes, hollow shapes and tubing. The working temperature is approximately 700 deg. F. In the extrusion process a cylindrical ingot is placed in an extrusion cylinder (which is part of a powerful hydraulic press) and forced through a die. The metal takes the shape of the die opening.

Reference Table of

ALTERNATES AND SUBSTITUTES

This section of METALS AND ALLOYS *continuing tabulation of alternates and substitutes for the "scarcest" materials is concerned with a phase of industrial equipment design that presents some of the knottiest substitution problems, since the use of many metals and alloys in electrical equipment depends on certain specific electrical or magnetic properties that only those individual materials possess. Nevertheless, considerable substitution is possible in "mechanical" components, like bearings, supports, housings, etc. and even in purely electrical applications by changing the design, sacrificing compactness or lightweight, etc. For previous sections of this tabulation, see M & A for January 1942, p. 80 (Household Products); March, p. 403 (Motor Vehicles); March, p. 404 (Engineering and Machinery Steels); and July, p. 68 (Brasses and Bronzes).*

SECTION 4—ELECTRICAL EQUIPMENT AND PARTS

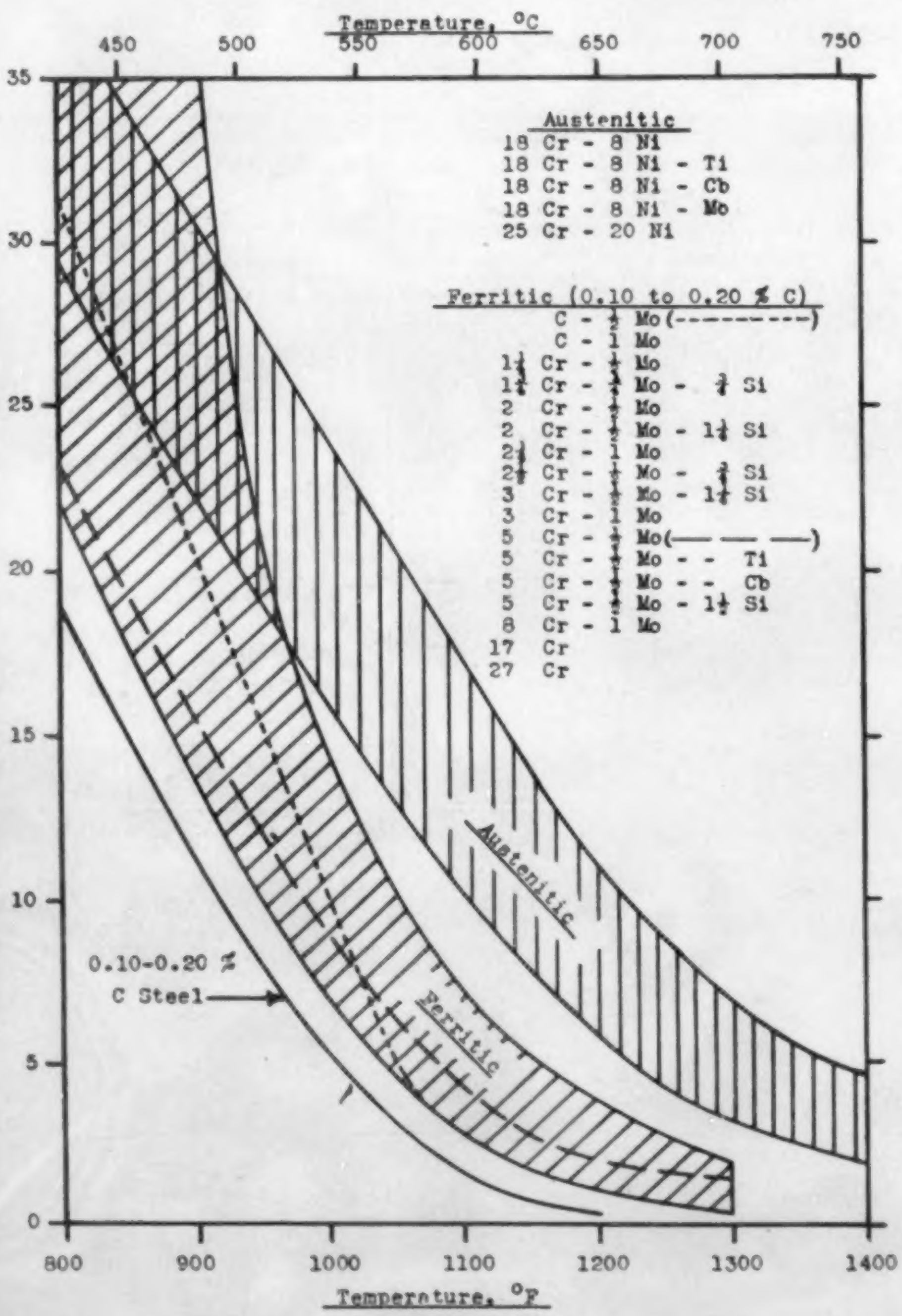
Part	Former Material	Substitute Material
Bearings, Motor	bronze or babbitt	iron-powder; silver lead; indium-plate
Bearings, Power Plant	cast - iron - anchored, thick tin-base babbitt	thin-wall bonded tin babbitts
Bearings, Sleeve	83⅓% Sn babbitt	Pb-Sb-As-1% Sn babbitt
Boxes, Conduit	brass, bronze	coated steel
Boxes, Outlet Fittings	brass, bronze	coated steel
Boxes, Terminal	aluminum castings	wood; cast iron
Brushes, Carbon	copper/graphite	silver/graphite
Brush Holders	aluminum die castings	formed steel
Circuit breaker contact arms, cross heads, supports, frames, hooks, etc.	aluminum castings	steel
Commutator riser joints	pure tin	silver brazing
Conduit, Rigid	galvanized steel	blackened steel
Conduit and cable fittings	brass, bronze	painted steel
Contacts	copper	silver laminates
Contacts	copper/tungsten	silver/molybdenum carbide
Contacts, Switch Spring	tin bronze	copper-silicon alloy
Floodlight Reflector	polished aluminum	silvered glass
Floodlight Socket Housing	aluminum die casting	zinc die casting
Floodlight Lens Ring	aluminum stamping	steel stamping
Floodlight lens ring clamp	brass	steel
Furnace Elements	nickel - chromium, nickel - chromium-iron	silicon carbide iron-base alloy
Housings, Control	aluminum	steel
Housings, Street light	aluminum	steel
Housings, Floodlight socket	aluminum die casting	zinc die casting
Housings, Luminaire	aluminum die casting	cast iron
Lighting Reflectors	aluminum stamping	phenol plastic; silvered glass
Luminaire Hood	aluminum die casting	cast iron
Luminaire Reflector	sheet aluminum	silvered glass
Lightning Arrester Casings and fittings	aluminum	galvanized steel
Loading Pots	copper	lead
Magnets, Permanent	36% Co Steel	17 Mo, 12 Co, Fe alloy
Magnet Bearing Brackets	aluminum die casting	zinc die casting
Meter Bases	aluminum die casting	zinc die casting
Meter Nameplates	aluminum	fiber
Metal Sockets	aluminum	sheet steel
Meter (watt hour) cover rings, register, seal bar, bayonets	aluminum stamping	steel
Nameplates	aluminum paints aluminum stamping	gray lacquer etched zinc; lead alloy; cast iron
Pole line insulator pins, cross arm braces	galvanized steel	black - copper - bearing steel
Relay covers, frames, and rotors	aluminum castings	steel
Resistance Windings (cold)	nickel - chromium iron, fine wire	ceramic resistors
Resistors, Control	nickel - chromium wire	cast iron grids
Resistors, Furnace	nickel alloy	iron-base alloy; silicon carbide
Solders, Dip	60 Pb, 40 Sn	90 Pb, 10 Sn
Solders, Mechanical	60 Pb, 40 Sn	79 Pb, 70 Sn, 1 Ag
Solders, Electrical (heavy)	pure tin	silver brazing
Solders, Wiping	62 Pb, 38 Sn	68 Pb, 23 Sn, 9 Cd
Springs, current-carrying	tin bronze (phosphor bronze)	beryllium-copper
Street light housings	aluminum	steel
Street light brackets	aluminum	malleable iron
Street light hangers	aluminum	silicon bronze
Street light reflectors	anodized aluminum	silvered glass
Telegraph - printer bases	aluminum	cast iron
Telegraph - printer small parts	alloy steel	carbon steel
Thermocouples	Chrome/Alumel	platinum/platinum rhodium
Thermostat Elements	nickel-steel/brass	liquid expansion devices
Transformer conductors	copper	silver or silver laminates
Tubing, Metallic	brass, bronze	coated steel
Tuning Inductor Blocks	aluminum	plastic
Wire (conductor)	copper	silver
Wire (non-conductor)	copper	steel

Alloy Steels for High Te

by R. F. MILLER, G. V. SMITH, and P. A. JENNINGS

Research Laboratory, United States Steel Corp., Kearny, N. J.

Fig. 1. Creep strength of various steels as measured at temperatures between 800 and 1400 deg. F.



Engineers are being required to select and specify materials to serve at ever-higher operating temperature, pressure and load. Yet no phase of design engineering has been so sorely in need of comprehensive, reliable data on probable performance factors as that of high-temperature service, and claims and counter-claims for materials and test methods have not tended to clarify the picture. This article, an attempt to bring useful order out of the general chaos, is based on a survey of reliable published data. It presents, chiefly in graphic form, comprehensive information on the comparative high temperature service properties—creep, tensile strength, allowable working stress, thermal expansion, thermal conductivity, oxidizability and air-hardening tendency—of several steels most widely used at high temperatures. The diagrams are intended to assist in the selection of materials rather than to be used as bases for determining permissible design loads, etc.—The Editors.

A CRITICAL SURVEY OF THE DATA on the properties of steels used at elevated temperature shows that the individual values for any steel of a given nominal composition range differ, the difference in some cases being quite appreciable. Nevertheless when all the data are plotted together to show the influence of temperature and composition, certain trends become apparent, even though the exact composition may vary within a specification range and there may be differences in the heat treatment employed by the various manufacturers or users of the same material.

The purpose of this article is to present a summary of the available data in the form of diagrams which show these trends more clearly than would a set of tables. These diagrams are intended to be used as an aid in the selection of material rather than for

h Temperature Service — I — Their Properties Compared

design calculations. Each is accompanied by a short description, including pertinent information not obvious from inspection of the curves themselves. There is also a brief discussion of the fundamental differences of behavior of metals at elevated and at ordinary temperature.

The properties summarized are:

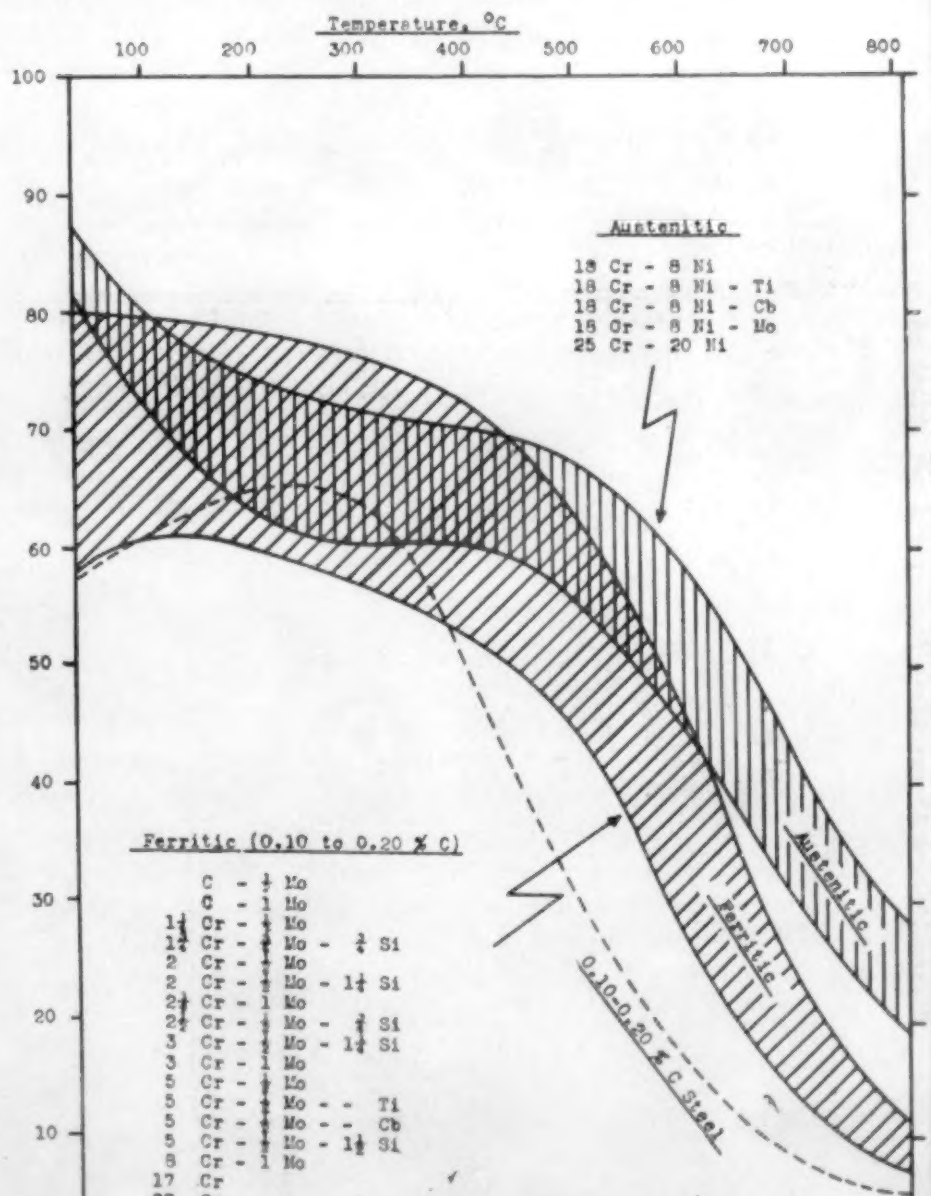
1. Creep strength
2. Tensile strength
3. Maximum allowable working stress (as set by 1941 ASME Boiler Code)
4. Linear thermal expansion
5. Thermal conductivity
6. Susceptibility to oxidation in air
7. Hardness after air cooling

Using the Diagrams

Two types of diagram are employed. The first type (Figs. 1 to 7) shows by means of bands and curves how each property of the steels investigated changes with change of temperature; the second type (Fig. 8) shows at a glance the influence of composition on creep and tensile strength at 1000 deg. F., on susceptibility to oxidation in air at 1700 deg. F., and on air hardening from 1700 deg. F.

The values used in the construction of these diagrams are based on data selected from the literature and on results of our own tests, in part hitherto unpublished. Each value is a conservative average of the available information, the sources of which are indicated in the Appendix, grouped in accordance with the diagrams. The nominal composition of the several steels is given on the diagrams, and they have been grouped as "austenitic" or "ferritic" depending on the form in which they are used. The austenitic materials are customarily annealed,* or annealed* and stabilized*; the ferritic materials are

Fig. 2. Tensile strength of various steels as measured at temperatures between room temperature and 1500 deg. F.



annealed,* or normalized and tempered; the three bolt steels (discussed under "Creep Strength" only) are quenched and tempered.

* *Note:* It should be noted that while "annealing" refers to a softening treatment for either the austenitic or the ferritic steels, this is achieved by rapid cooling of the austenitic steels in air or water, and by slow cooling of the ferritic steels, usually in the furnace. The "stabilization" of the austenitic materials is a reheating operation carried out to avoid intergranular corrosion by controlled precipitation of the carbide particles.

Variation in heat treatment may cause a larger change in the creep or tensile strength than a minor change in composition; in order to simplify the diagrams the individual heat treatments are not shown, and such variation in the stated properties as arise from difference in heat treatment is included within the bands. It appears that the number of grades of steel to be used at elevated temperature is greater than is warranted by the differences in properties.

It should be noted that information is not available on all of the properties of all of the steels examined, and hence the groups are slightly different on the various charts.

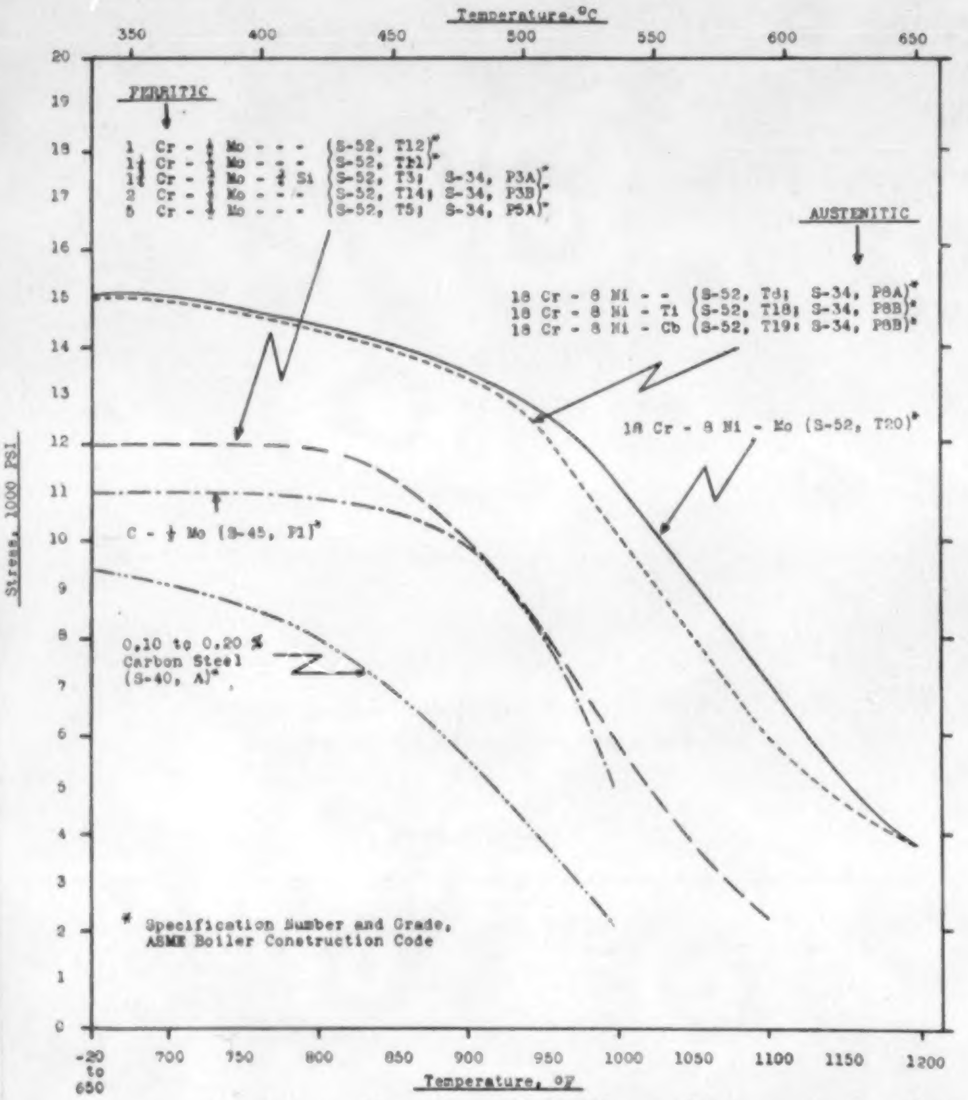
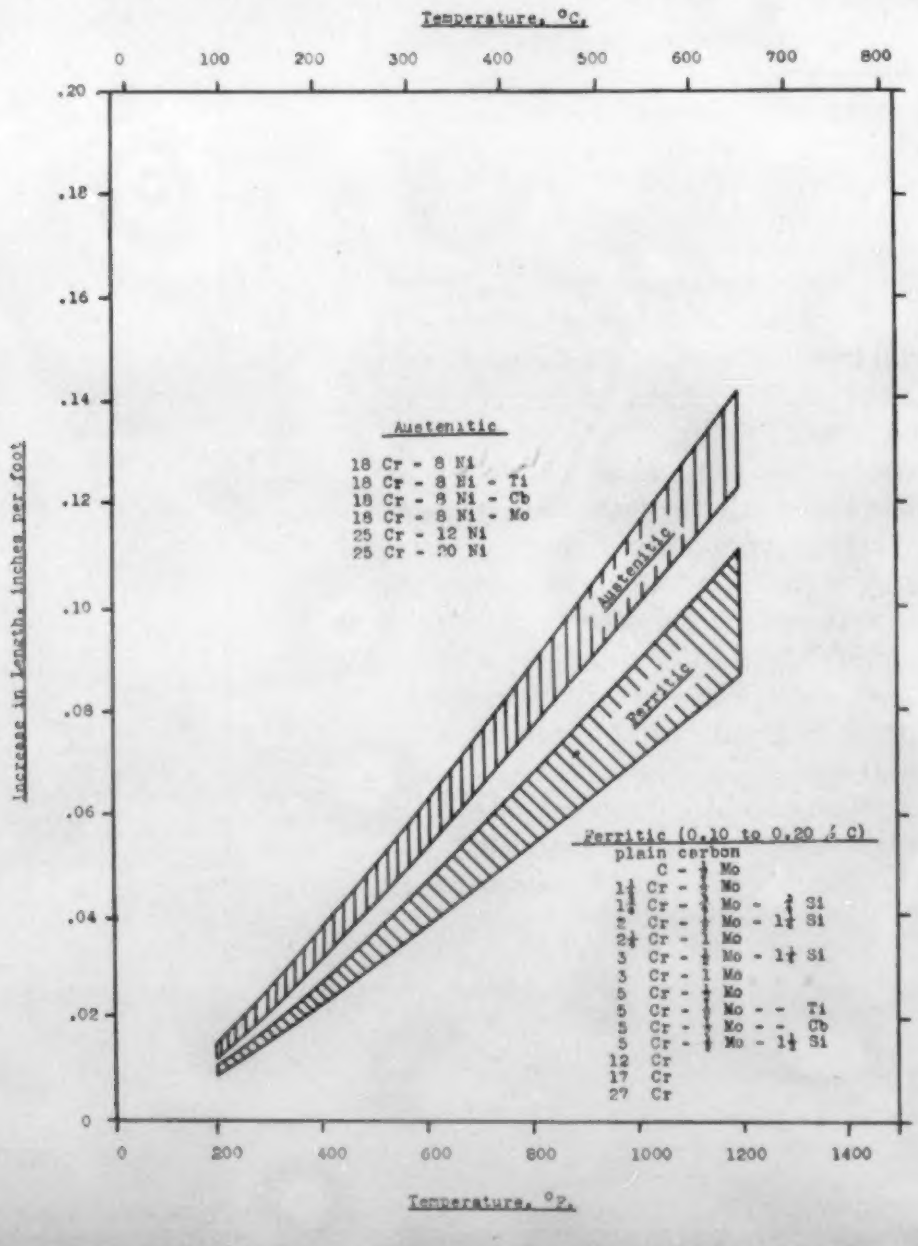


Fig. 3. Maximum allowable working stress of various steels for temperatures between —20 and 1200 deg. F. (as set by 1941 ASME boiler code)

Fig. 4. Linear thermal expansion (increase in length) in inches per foot in going from 70 deg. to any temperature between 200 and 1200 deg. F.



Creep Strength

Fig. 1 shows the influence of temperature between 800 and 1400 deg. F. on the creep strength of the several steels. The indicated creep strength is the stress for a creep rate of 1 per cent per 10,000 hrs. (1 millionth in. per in. per hr.).

Of the steels included in this diagram, those with the highest creep strength are the high chromium-nickel austenitic materials, whose creep strengths are shown within a band. Plain 18 Cr-8 Ni has the lowest creep strength of the steels in this group. Addition of titanium to 18 Cr-8 Ni may slightly increase its creep strength. Addition of columbium or molybdenum is beneficial. 25 Cr-20 Ni is slightly stronger than plain 18 Cr-8 Ni.

The next strongest materials are the ferritic steels which contain from 0.10 to 0.20 per cent C, with addition of one or more of the elements chromium, molybdenum, columbium, titanium or silicon. The creep strength of steels of this type also lies within a band; the list of compositions included in this band is given in Fig. 1. Individual curves for C-½ Mo and for 5 Cr-½ Mo steel are superimposed on the band in order to show that their relative order of creep strength reverses at about 1000 deg. F., above which temperature scaling and structural changes become significant in steels without chromium. Increase of molybdenum content from ½ to 1 per cent increases the creep strength of carbon-molybdenum and chromium-molybdenum steels.

Quenched and tempered bolting steels (SAE 3140, 4140, and 4340) occupy a special category. They have relatively high creep strength below 900 deg. F., but rapidly lose their high strength above this temperature owing to the accelerated spheroidization of the tempered martensitic structure. SAE 4140 (1 Cr-¼ Mo) has about the same creep strength as C-½ Mo steel; SAE 3140 (½ Cr-1¼ Ni) has about the same creep strength as carbon steel; SAE 4340 (¾ Cr-¼ Mo-1¾ Ni) is intermediate, having about the same creep strength as carbon steel above 900 deg. F. and somewhat superior creep strength below this temperature.

The data for the creep strength of 0.10 to 0.20 per cent C steel are presented for comparative purposes, even though this material is not useful over the entire temperature range shown in Fig. 1. Carbon steel (and SAE 3140) has the lowest creep strength of the steels included in Fig. 1.

Tensile Strength

Fig. 2 shows the influence of temperature on the tensile strength of various steels between room temperature and 1500 deg. F. (The standard elevated temperature tensile test, described in ASTM Specification E-21-37 T, prescribes a strain rate of from 6 to 15 in/in/hr. but in how far all the tests cited conform to this specification is unknown.) The increase in tensile strength observed in 0.10 to 0.20 per cent C steel in the "blue brittle" range (300 to 600 deg. F.) occurs also in some of the low alloy ferritic steels. Addition of chromium tends to eliminate this phenomenon; at about 3 per cent Cr the effect has almost disappeared. In general, alloying elements tend to increase the tensile strength of carbon steel. Above 800 deg. F., the austenitic steels begin to be superior to the ferritic steels.

Maximum Allowable Working Stress

Fig. 3 shows the maximum allowable working stress (as set by the 1941 ASME Boiler Code) for 0.10 to 0.20 per cent C steel and certain alloy steels between —20 and 1200 deg. F. Up to 650 deg. F., the maximum allowable working stress is the same as at 650 deg. F. The steels are listed by nominal composition, accompanied by the ASME specification number and grade (in parentheses) which completely identifies the material.

The general trend of the curves is the same as in Figs. 1 and 2. The austenitic materials have the highest allowable stress, the C-Mo and Cr-Mo ferritic steels have intermediate values, and the carbon steel has the lowest allowable working stress. In each case, the allowable stress appears to be about one-half of the stress for a creep rate of 1 per cent per 10,000 hrs.

Thermal Expansion and Conductivity

Fig. 4 shows the total linear thermal expansion, in terms of inches per foot, of the various steels as they are heated from room temperature to any temperature between 200 and 1200 deg. F. The thermal expansion of the ferritic steels decreases with increasing chromium content, following the order of the steels in the list in Fig. 4; that of the austenitic steels is larger than of a carbon steel, and is decreased by increasing alloy content in the order shown.

(To be Concluded)

Radiography of Spot Welds — I

by ROBERT C. WOODS, JOHN C. BARRETT and T. W. DIETZ

Director of Research, Metallurgist, and Research Engineer, Respectively, The Taylor-Winfield Corp., Warren, Ohio

Product-quality, process-control and accuracy of final inspection are closely related. In the field of spot-welding—now making a great contribution to faster production of war products—a real need has existed for clarification of some of the factors in X-ray inspection of spot welds. In this first instalment of their article the authors discuss the "rings" and "sunbursts" observed in radiographs of spot welded metals of various kinds, with particular emphasis on aluminum alloy welds, and explain the relation between these phenomena and actual spot-weld quality. The more general utilization of X-rays for studying spot-weld structures is recommended.

—The Editors.

DURING THESE HECTIC days of industrial demand for speed, and yet more speed, in the construction of air, land, and sea warcraft, the spot welded metal joint has assumed an importance never previously accorded it in the leisurely years of unpreparedness.

Under such stimulus, modern concepts in the spot welding art have raced on at terrific pace, giving rise to all manner of novel and ingenious mechanisms and techniques. Unfortunately, so swift have been these innovations, and so varied the applications, that completely satisfactory inspection methods have apparently lagged behind. Past lessons have taught us beyond doubt that the quality of a product depends not only on the best possible control of manufacturing processes but likewise on the accuracy with which the final product can be inspected.

Applying the second factor directly to spot welds, it seems that destructive, physical tests are more advanced than non-destructive ones. But we cannot submit spot welds which are destined for use—or any other kind of weld, for that matter—to shear, fatigue, or corrosion tests or to microscopic examination. As in other industrial fields, we can only spot-check with specially prepared samples which may or may not bear a true relation to the finished structure. While other methods are now under investigation, only X-ray inspection has gained any considerable foothold as a routine non-destructive inspection tool for factory use.

Present radiographic techniques, however, have certain drawbacks in this connection and perhaps the greatest of these is *misinterpretation of the recorded spot weld image*. Much fine work is now being done, aimed at correlation of spot weld radiographs with actual soundness, fatigue strength, or corrosion resistance of the welds. Such results, at the best, can be but empirical until it is possible to point to each and every radiographic marking and state with certainty its relation to actual conditions within the weld.

This radiographic misinterpretation has resulted from our ignorance and is therefore not deliberate in character, yet its unfortunate influence is in no way mitigated by this fact. It is the intent of this discussion to present a few details which the authors have been fortunate enough to come upon during their routine X-ray examination of spot welds. It is hoped that some of these may prove to be new and perhaps of value to other workers in the same field.

In viewing radiographs of spot welded joints it requires little experience to detect cracks, porous areas, or gas pockets wherever they exist so as to be recorded on the X-ray film. Their images are reproduced there simply because they offer but scant resistance to passage of X-rays and thus the photographic emulsion receives a higher radiation dose at these points than from neighboring areas. However, other images appear that do not seem so readily explainable. Most easily noticed is a heavy ring around the spot weld periphery, as illustrated in Fig. 1. The ring is present in all spot-weld radiographs, whether

the weld is the bond between aluminum alloys, steels, or any other metals so far tried. But while these rings—regardless of the metals welded—always appear to be somewhat the same, their metallurgical natures are actually many and varied.

In conjunction with the rings in aluminum alloys, sometimes the inner nugget may contain radiographically dense streamers arranged spokelike and simulating a sunburst. And occasionally the weld nugget periphery may appear ragged, or again its contour is an unbroken circle. Since these conditions can be changed and reproduced at will, the prospect that X-rays may yet become the inspection device so long desired is not an illfounded one.

What Causes the Rings?

To confine the subject for the present to the ring phenomenon, it is widely supposed these are radiographically produced by extra metal at the points in question pushed outward from the weld nugget into the interspace between the faying surfaces, plus slight circular protuberances on the surfaces where the welding tips have pressed as in Fig. 2. It is the theory that X-rays passing through these areas would there encounter more actual metal than at other places, they would not penetrate so easily, and a resultant light ring would appear on the exposed X-ray film. This is a sound, logical, and true conclusion, but only a small part of the story. The rest is more fundamental.

For a fuller explanation of these rings, sunbursts, and other markings, we must glance briefly at certain facts related to the absorption of X-rays in matter.

A tungsten target X-ray tube—such as is commonly used for industrial radiography—when excited by any given voltage, emits radiation over a relatively wide range of wave lengths. There will, however, be a narrow range at which the output intensity is at a maximum and for purposes of convenience, that range may be considered as the one which does most of the radiographic work. Assuming that such a tube is operating at 30 kilovolts, most of its output will then be X-rays in the region between 0.5 and 0.6 Angstrom units, as in Fig. 3.

Since the most readily available figures are for X-ray of wave length 0.631 A.U., this value has been used in the Table, where the various elements shown absorb X-rays in proportion to the coefficients listed. Thus, the ratio of X-ray absorption between magnesium and aluminum is 3.00 to 3.73. This difference is so slight that if equal thicknesses of magnesium and aluminum sheet were placed on a single film and exposed to X-rays simultaneously, the resulting variation in film exposure under the two metal sheets would be indistinguishable to the eye. It will be noted, however, that for X-rays of 0.631 A.U., the difference between the absorption coefficients of aluminum and those of the other elements listed is great. Copper, for instance, is 10 times as absorbing, and tungsten is 20 times. Evidence of this situation is nicely demonstrated by placing on one X-ray film a sheet of 2 S pure aluminum and an identical thickness of 24 S aluminum alloy with its 4 per cent Cu content. When this set-up is radiographed, that section of film which has recorded the image of the 24 S sheet will be markedly lighter than that of the 2 S.

Throughout any discussion of radiographic interpretation, it must be kept clearly in mind that photographic density and specimen density are two distinctly different factors and indicate opposite conditions. In radiographing a piece of metal, for example, an increase in the density of the sample will result in a decrease in the photographic density of the X-ray film, and a decrease in sample density will cause a corresponding increase in photographic density. This is only true when an X-ray film is being viewed in the usual manner; that is, by transmitted light. When a print has been made of the film, then of course rings which were white on the radiograph film will appear dark on the print and vice versa.

Presence of "Heavier" Metals

The relation between X-ray absorption coefficients and spot welds will become more apparent by reference again to Fig. 1. Actual measurements show that while some part of a ring, such as is illustrated, could be due to extra metal pushed up as previously mentioned, still the outside ring dimensions are beyond this point. Such a condition could only be ex-

Fig. 1. Typical "ring" around the periphery of a spot weld as observed radiographically.

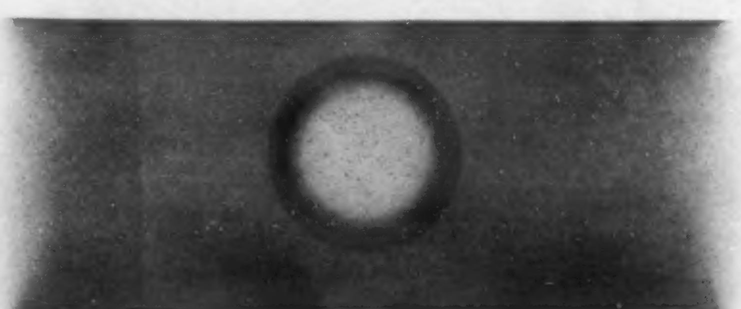
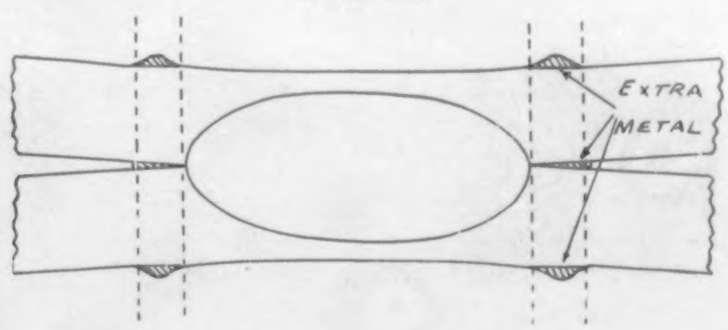


Fig 2 Schematic representation of radiographic effects produced by "squeezing" of the welding electrodes.



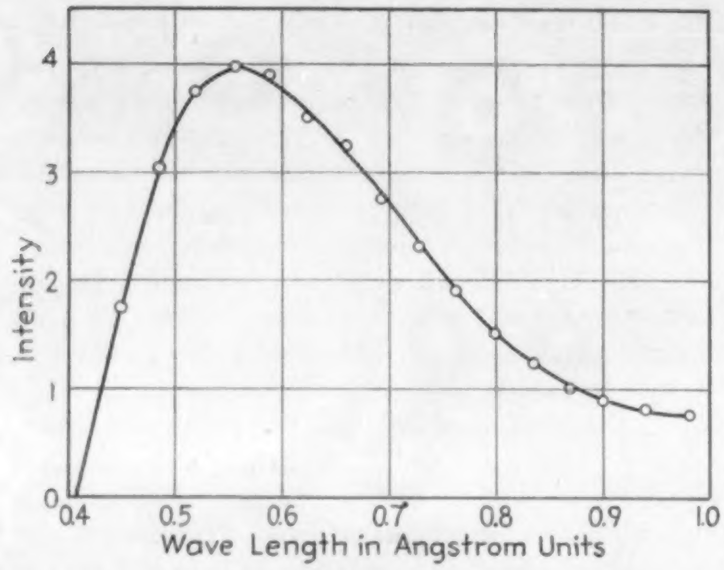


Fig. 3. Output-intensity vs. wavelength curve for X-ray tube operating at 30 kv.

plained by the presence in that area of some element considerably heavier atomically than the surrounding material. In 24 S and 17 S this could be a copper compound, in 52 S chromium and iron, in 3 S manganese, but the ring present in a 2 S weld could be due only to the iron impurity, which exists in 0.026%. That this has been established, gives some indication of X-ray sensitivity possibilities. These elements are naturally not present there in the free state.

To eliminate the purely mechanical factor of pushed up metal around the weld, fused spots or slugs were formed in single sheets of aluminum alloys by the usual spot welding expedient of placing the sheets between two copper welding tips and firing a heavy current through the sample. Such a slug in 24 ST Alclad is shown in Fig. 4. The surfaces of these prepared samples were then ground and polished to a high finish so that no trace of the "spot welds" could be seen. Upon radiographic examination, the familiar rings appeared, somewhat diminished in clarity, but making it certain they are an inherent property of aluminum spot welds. To make doubly sure, several ordinary two-sheet welds were sectioned in half in a plane parallel to the sheet surface and all outer surface uneveness removed. Radiographic results were identical.

Further careful measurements showed these high metallic density rings to exist completely outside the fused zone in an area that had at no time been melted.

Metallographic study disclosed that in 24 ST Alclad spot welds, these radiographic rings were produced by the presence of dense stringers of a eutectic composed of aluminum solid solution and the aluminum-copper-magnesium constituent. It is also probable that small amounts of $CuAl_2$ and aluminum -copper - iron - manganese constituent are present.

A section at 50X shows these eutectic stringers shooting outward from the heat-affected zone into unaffected parent metal, as in Fig. 5. Fig. 6 shows an eutectic area at 500X. While in this plane the eutectic appears as fine lines, it must be remembered that in the plane at 90° to the X-ray path, these lines in reality are sheets or layers of high absorption coefficient material stacked one above the other.

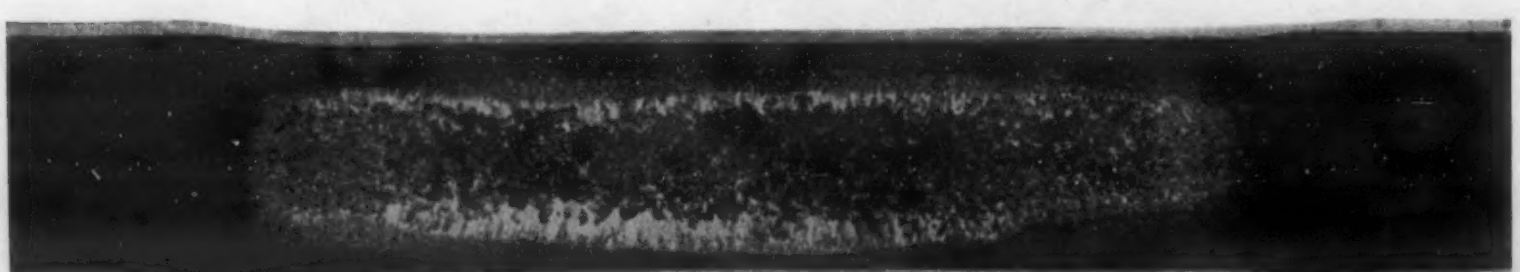
Assuming the situation is as stated, then three questions naturally come to mind; namely, where does the eutectic come from, what is the mechanism by which it arrives at its final site, and, how does its change of location affect weld fushion?

X-ray methods shed considerable light on the first question. In addition to the outermost, thick ring appearing in a spot weld radiograph, there is generally visible a thinner ring just inside and concentric to the eutectic circle. X-ray absorption of the inner ring is much lower than that of either the outer ring or the parent metal, and its penetrability increases roughly as that of the outer ring decreases. Both rings are plainly visible in Fig. 1.

Re-Location of the Heavier Constituents

It is therefore evident that the circular area immediately inside and adjacent to the eutectic is of extremely low density and has lost some element, or elements, of high atomic weight. What more logical than to assume that the copper, manganese, chromium, or iron eutectics (depending on the alloy used) have migrated from these regions out along the grain boundaries to their new stations? From the metallurgical standpoint, this is only an assumption, but from the X-ray standpoint, it is practically a certainty. Also, it is further bolstered by the fact that the low X-ray absorbing region exists in an area which has been very little heated, so that only the low melting point eutectic would have a chance to move.

Fig. 4. Fused "slug" produced in spot welding 24 ST Alclad.



As to the question of why the eutectic should move at all, there are at least three possible answers. The first is pressure, the second is electro-magnetic force, and the third is a combination of the first two. The pressure theory certainly needs little elaboration. If any peripheral constituents of the weld are molten, then it would seem only natural to assume that the pressures exerted would tend to squeeze this material out along grain boundaries.

In addition to pressure, however, there are powerful electromagnetic forces present during the weld time and these should by no means be overlooked. Some workers (A. M. Unger, H. A. Matis, & W. A. Knocke, *The Welding Journal*, Vol. 20, Jan. 1941, p. 42) recently advanced the theory that these forces caused a violent turbulence or stirring action in the molten weld metal, more especially in spot welds made with alternating current. In support of this theory, they outline the configuration of such an electromagnetic field as would exist during the spot welding cycle and they show in what directions that force would tend to propel the molten metal molecules, as in Fig. 7. In passing it should be remarked that this diagram is correct as to field forces, but the direction of weld metal flow is probably only applicable to spherical, oval, or columnar welds. As further evidence, these workers submit metallurgical sections of A. C. spot welds in which the current was applied for varying lengths of time and their illustrations certainly seem to support their hypothesis.

Fig. 5. Eutectic stringers running from heat-affected zone into parent metal of spot welded 24 ST Alclad (50 magnifications).

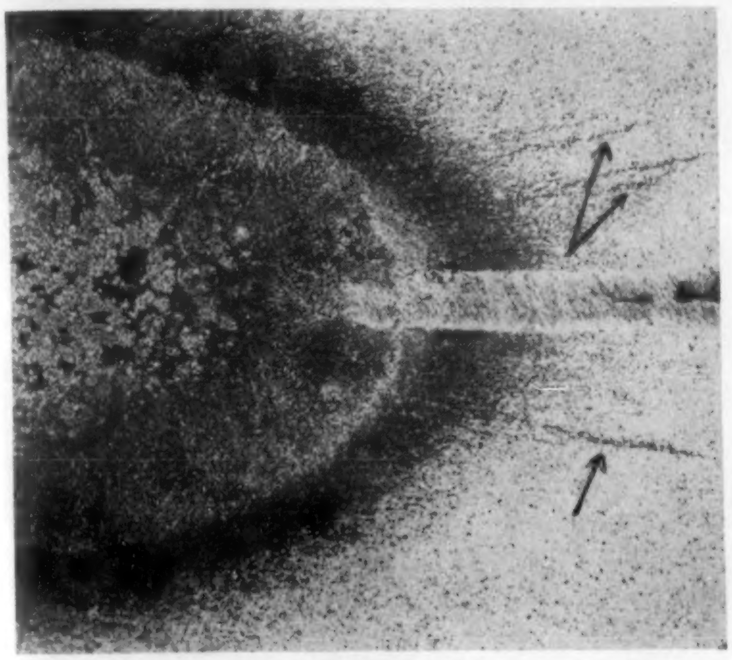


Fig. 6. A eutectic stringer in a spot weld, magnified 500 times.

In an attempt to test this subject further, the authors used a technique more commonly applied to biological studies; that of the combined X-ray and tracer methods. At first, small bits of 0.010 in. tungsten wire were imbedded in the surface of one 24 ST Alclad sheet. This surface was then used as an interface and spot welded by A. C. to a similar opposing sheet having a smooth surface. That there is motion of a violent nature may be seen by the radiograph in Fig. 8, which shows clearly what position these carefully aligned wires finally took.

The element tungsten was chosen on several counts. It has high electrical resistivity, a high melting point, low magnetic permeability, and does not alloy with any of the welded constituents. Perhaps more important, its X-ray absorption coefficient is way beyond that of any other element present in the weld, so it would be expected to stand out sharply in a radiograph. While this experiment clearly demonstrated a turbulence, it gave no directional indication whatever. In the next procedure, finely divided tungsten powder was arranged in a machined circular groove so that the groove diameter would be considerably smaller than the final weld nugget diameter. With this tungsten filled groove between the interfaces, a number of A. C. welds were so set up and made that the centers of the groove and welding tips were as nearly concentric as possible. The number of welding cycles—time—was varied from the point at which weld slugs were barely melted up to a condition of over penetration, and several welds were made at each setting.

Although radiographic study of the resulting tungsten powder distribution does not absolutely prove the electromagnetic stirring theory, such a theory would capably explain the results obtained. The radiographs in Fig. 9, and numerous others, show that when A. C. is applied for very short time periods, the first powder movement is towards the center of the weld, which is to be expected on the basis of the theory discussed. Thereafter, as the heating time is continued, the powder moves outward also until

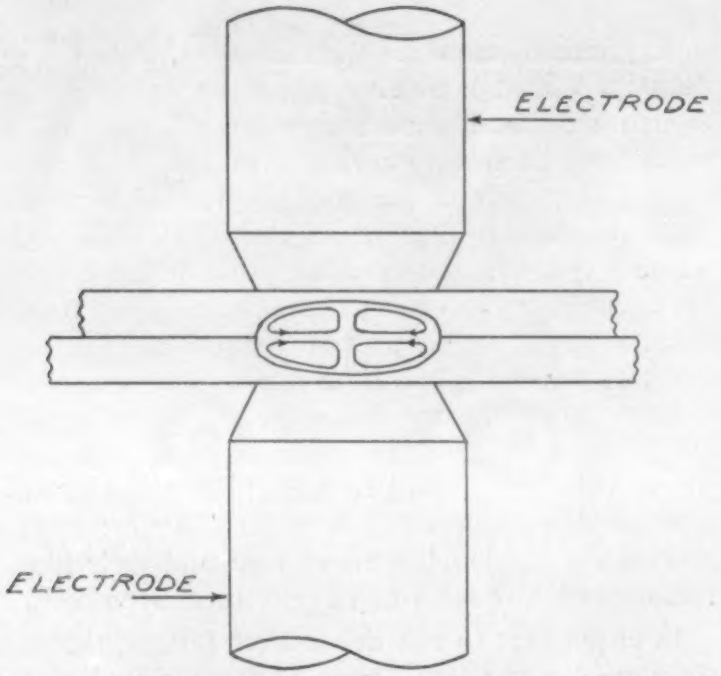


Fig. 7. Diagram (according to Unger, Matis & Knocke) showing the direction of electromagnetic propulsion of molten metal during spot welding.

there is a fairly even dispersion throughout the weld area.

In passing it might be interesting to note that metallurgical study of the dispersed tungsten powder revealed that much of it had become sintered. This fact suggested to the authors a somewhat similar experiment by which it might be possible to measure the temperature of the molten nugget during welding and this line is now under investigation.

Effect of the Type of Welding Process

The originators of the electromagnetic stirring theory also state that it is unlikely such an effect exists in welds made by a rapid discharge apparatus, since the short weld time does not allow motion to take place. Such, however, is definitely not the case. In the work just mentioned, weld times nearly as short as condenser discharge welds were used and the stirring was found to be present. Moreover, the experiment was duplicated on a condenser discharge apparatus with the heat times and wave shapes varied over quite a range. In every instance the tungsten powder—instead of being stirred—was immediately shot to the periphery of the nugget, and it stayed there no matter how long the time. To make certain that powder located anywhere in the weld zone would behave similarly, some was imbedded in grooves machined to form an X. Results were identical, all tungsten moving out to form a peripheral ring, as shown in Fig. 10.

From this evidence it would appear reasonable to assume that electro-magnetic motion does take place in both A. C. and condenser discharge welds, but in the latter the force is not the same directionally. It is possible that such a difference may be due to the nature of alternating current, giving, as it may, a series of jolts to the molten weld metal rather than one continuously applied force. In fact, it is difficult to imagine how these two effects could be identical, except perhaps, by use of half an alternating current cycle.

As to whether this electromagnetic force contributes to the driving of the melted eutectics out into the parent metal grain boundaries, it is impossible to say. Until such time as more definite facts are at hand, it does not seem logical to disregard this force.

Relation of "Rings" to Weld Quality

Returning to the eutectic ring, there is an opinion prevalent that the size, shape, and density of these rings give direct indication of the amount of fusion that has occurred in the weld. It is certainly true that where there is no fusion at all, there is unlikely to be a ring, for clearly the eutectic around the weld periphery must melt before it can migrate. Moreover, if there has been sufficient heat around the outside of the weld to melt the eutectic, then the center must have been at a considerably higher temperature. Further than this, however, it is dangerous to go. By reference again to Fig. 9, it will be seen that the weld made in which the tungsten was only slightly disrupted has a healthy-looking ring around it. Yet that particular weld turned out to be barely fused.

As heating and fusion are continued, the eutectic stringers sometimes increase in length, sometimes in

Fig. 8. Radiograph of spot-welded 24 ST Alclad in which bits of tungsten wire had been carefully aligned before welding. Note the extent to which the wires were moved out of position during the weld cycle.

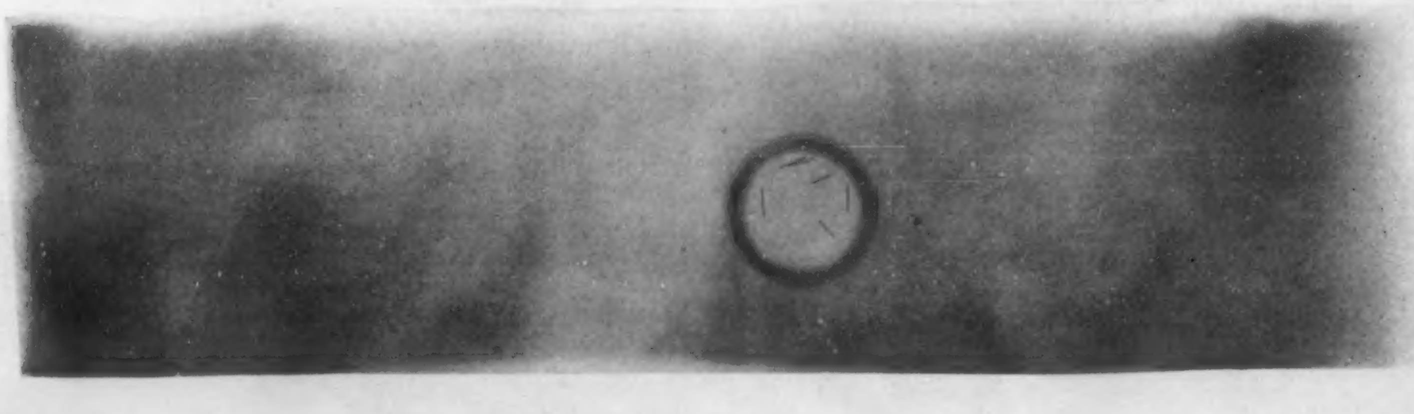


Table of relative X-ray absorbing power of various metals

Element	Atomic No.	Absorption Coefficient at 0.631 A.U.
Magnesium	12	3.00
Aluminum	13	3.75
Chromium	24	22.00
Manganese	25	25.00 (?)
Iron	26	27.50
Copper	29	37.20
Tungsten	74	75.00

number, and sometimes both. The effect of the first is to fatten the radiographic appearance of the ring, and that of the second to increase radiographic film transparency in that area by increasing X-ray absorption. With either of these variables possible, it does not seem safe to depend on the radiographic appearance of the eutectic as a measure of weld soundness. To do so would require that the examined weld ring be measured for thickness and then its image on the film be graded according to its absolute film density by means of an optical densitometer. Both these calculations would then have to be compared with a standard spot weld exposed simultaneously. It would be a tedious process indeed for routine inspection.

If the range and utility of X-rays as a tool for the inspection of spot welds is to be extended, it would appear more logical to apply them directly to studies of the spot weld structure itself. If later, the results of such studies can be used in conjunction with what we now know about the eutectic rings, so much the better.

As evidence that radiographic techniques are capable of revealing structural changes in spot welds—Fig. 11 shows the radial, spokelike appearance mentioned earlier. This condition shows up clearly by radiograph although the lines are too fine to show up well in a radiographic paper print. These spokes also prove to be the same eutectic that exists in the radiographic rings and probably represent the same type of segregation as that existing in cast ingots.

The aluminum and magnesium alloys are ideal radiographic subjects, because practically any of their alloying elements have relatively high X-ray absorption coefficients. But useful data can also be obtained by similar methods when applied to other metals and alloys. It is, for example, possible to disclose structural and chemical changes taking place in spot-welded stainless and tungsten steels.

(To be concluded)

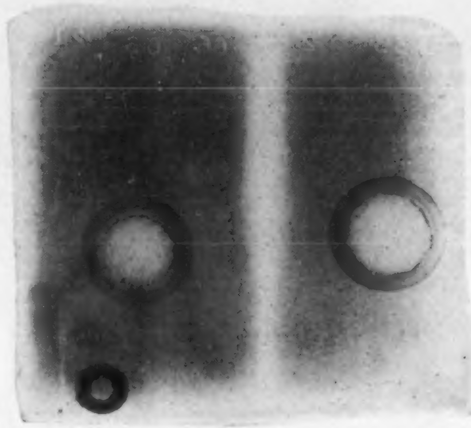


Fig. 10 Final (circular) position of tungsten powder originally embedded to form an "X," after condenser-discharge spot welding.

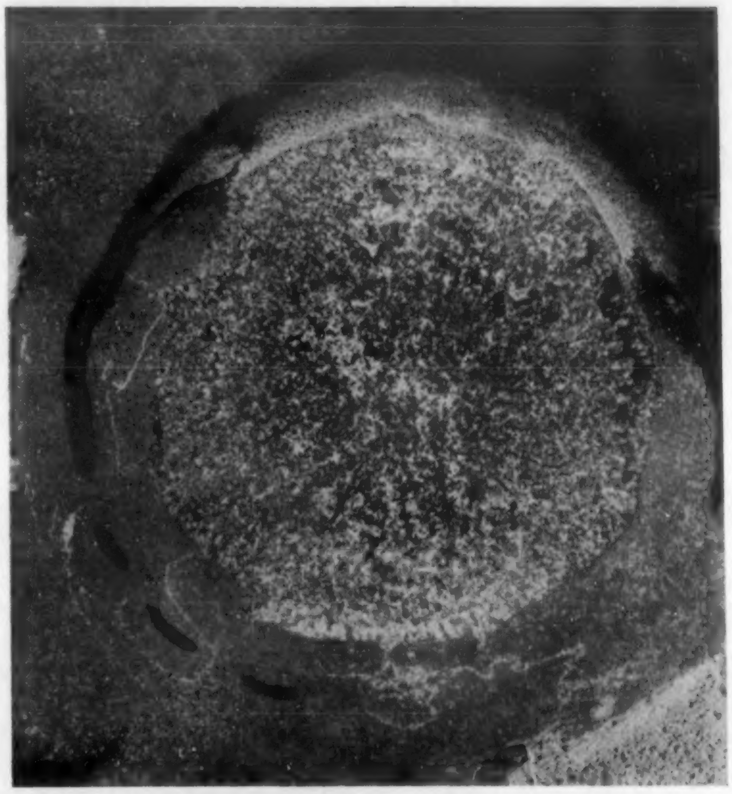


Fig. 11. Radial, spokelike appearance—under the microscope—of a spot weld. These "spokes" also show up clearly on a radiograph (although the latter reproduces very poorly in the printing process).

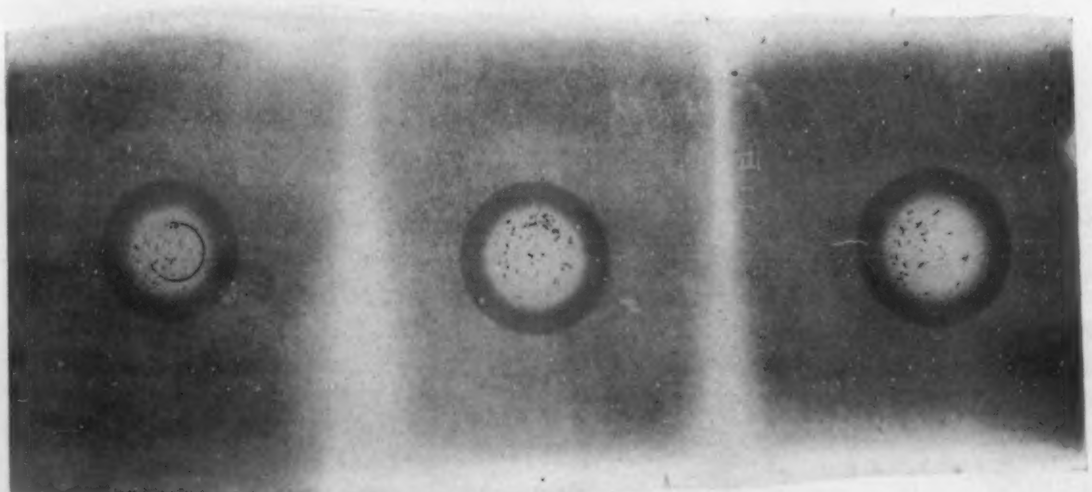


Fig. 9. Radiographic demonstration of movement of tungsten powder originally placed in a machined circular groove, on the application of a.c. welding current for increasing times.

(Editorial, continued from page 419)

Commercial Variations

The following has been received from Dr. John Johnston, director of the research laboratory of the U. S. Steel Corp. at Kearny, N. J.:

> I suggest, as a suitable subject for an editorial, the topic that the properties of a steel meeting a given chemical specification should be represented by a range and a band, and not—as is commonly done—by a point and a curve; and that this fact implies not that the actual measurement is not accurate, but that unavoidable differences in manufacture, within the specifications, may cause a variation of 10 per cent (or even more) in some of the mechanical properties. The point is that many engineers and designers think that any steel they buy to a given specification will have the precise properties stated. A better and wider realization of the actuality would help greatly in lessening the number of needless compositions of steel demanded by the user.

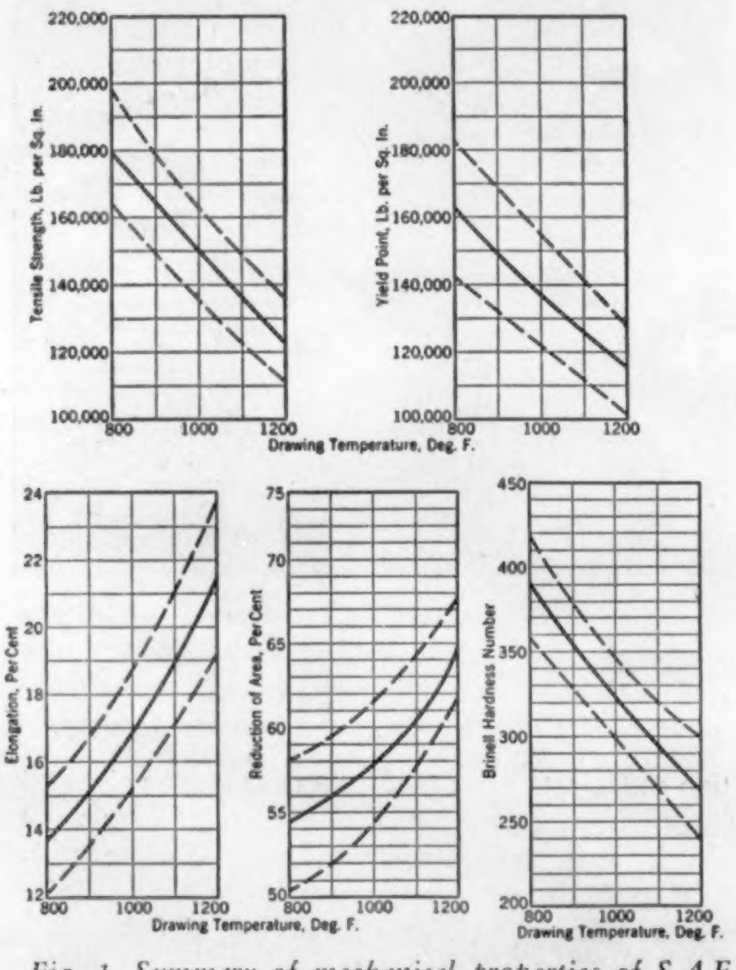


Fig. 1. Summary of mechanical properties of S.A.E. Cr V steel 6130. Maximum and minimum values are represented by dashed lines and averages by solid lines. (S.A.E. Journal, Vol. 22, 1928, pages 55-64; Vol. 29, 1931, pages 480-481.)

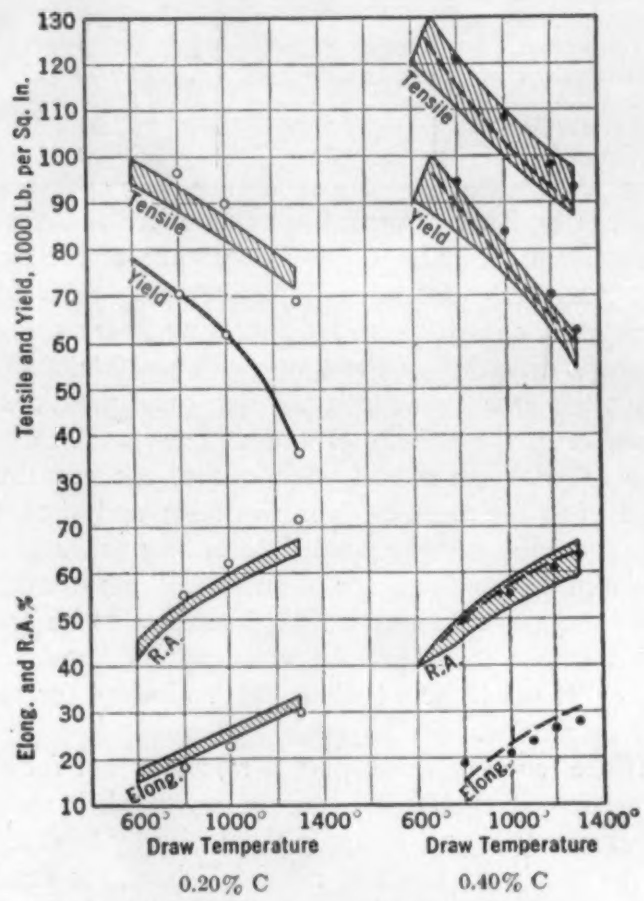


Fig. 2. Properties of 0.20 and 0.40 per cent C steels water quenched, small sections.

Bands, Sisco.
Circles, Dawe.

Bands, Sisco.
Dashed line, Sisco, most probable.
Points, Bethlehem

Sisco, "Alloys of Iron and Carbon," Vol. 2, 1937.
Dawe, "Steel Physical Property Atlas," 1936.
Bethlehem Alloy and Special Steels, 1935.

A committee of the S.A.E. tackled this matter 15 years ago, using SAE 3130 and 6130 as guinea pigs. The spread of results from four lots of 6130 is shown in Fig. 1. Sisco later assembled similar data for 1020 and 1040, and these with still other data, are collected in Fig. 2. These two figures, and several other similar ones, have already been used in the last edition of Bullens's "Steel and Its Heat Treatment."

Ample evidence substantiating Dr. Johnston's comments is thus already on the record, but, as he says, this is a time when these facts need emphasis.

—H. W. G.

METALLURGICAL ENGINEERING news

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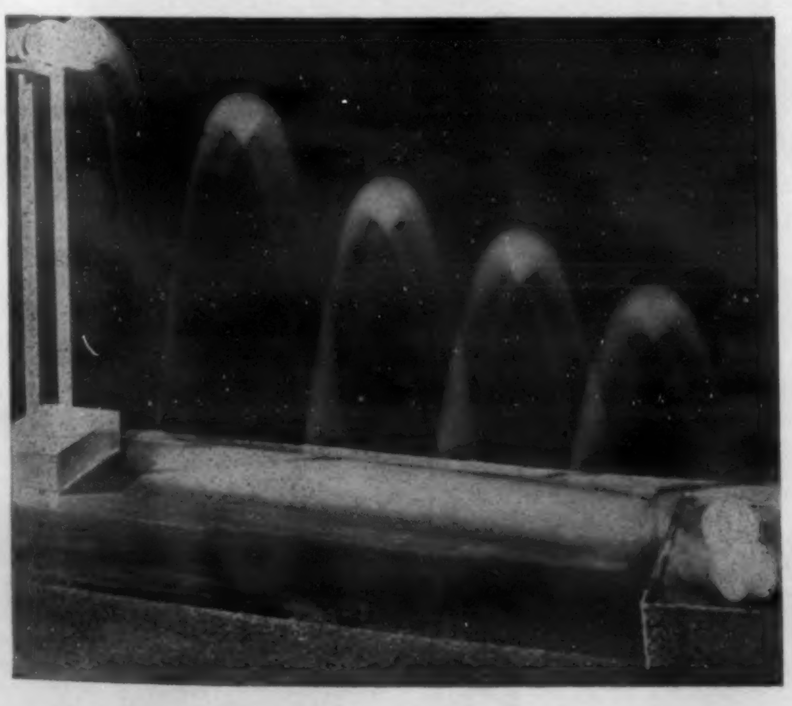
Bounceless Balls Illustrate Principle

Westinghouse engineers have found that a steel ball half-filled with metallic powder will not bounce, as this time-exposure photograph illustrates. Two balls of the same weight—one empty and one containing powder—were dropped simultaneously from the top of the posts, to the left.

The empty ball left a looping trail of light as it bounced four times on the steel plate. The ball containing the powder rolled without bouncing, as shown by the straight streak of light on the plate. Rough surfaces of the metal powder particles created frictional heat, as they slid over each other, dissipating the energy the ball would have used in bouncing, the engineers explained.



This discovery has been used to prevent poor connections by eliminating bouncing and chattering in electrical relays — delicate, swift-acting switching devices used in communications systems. The relay contacts are made hollow and partly filled with powder, or special hollow powder containers are attached to the contacts.

Welding Magnesium, Etc. with Helium

Helium has over five times the specific heat of air and, when in motion, prevents heat accumulation around the weld, thereby keeping it cooler and giving a better fusion and penetration with less distortion than other welding processes.

That is the claim of Thomas E. Piper, process engineer of *Northrop Aircraft, Inc.*, Hawthorne, Cal., in describing "Heliarc" welding, a process particularly adapted to welding magnesium and developed by Northrop engineers.

The process permits the arc welding of magnesium sheets, extrusions, and tubing into structures simpler, lighter and stiffer than is possible in conventional duralumin construction.

Adapted to Stainless Steel

It is also adapted to stainless steel, where thicknesses of less than 0.01 in. may easily be welded; with certain modifications, it is adapted to ferrous and copper alloys, including Inconel, Monel, and some of the carbon steel alloys. Sponsors claim that for high temperature melting and heat resisting alloys "Heliarc" welding has proved successful where other welding methods have failed.

Use of magnesium welded structures eliminate thousands of rivets that go into the conventional plane. Rivet heads on the fuselage and wings, even though countersunk, produce resistance to air

(Continued on page 452)

passage or "parasite drag." In the future, welded magnesium aircraft can be finished as smoothly as a fine automobile.

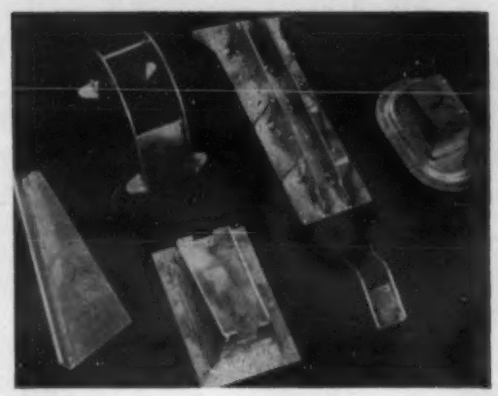
While magnesium has been used for some time in aircraft for engine parts, wheels and accessories, it has not been used extensively as a primary material. Mr. Piper claims that the "Heliarc" process makes possible the all-magnesium plane.

Magnesium alloys will be cheaper than aluminum alloys in a very short time, continues Mr. Piper. To produce a ton of aluminum from bauxite 24,000 kw.-hrs. are needed; for a ton of magnesium, 18,300 kw.-hrs. are required, the latter having 54 per cent more volume.

Stiffness and Rigidity

Though magnesium alloys are 35 per cent lighter than aluminum alloys and 21 per cent of the weight of steel per unit volume, their weight-strength ratio is comparable to aluminum alloys. They have the stiffness and rigidity not obtained in other alloys.

Magnesium alloys are not inflammable when properly processed. Castings containing defects have been repaired by "Heliarc," the welds being equal or stronger than the parent metal. They are denser and more corrosion resistant. Almost any thickness can be welded. A weld-



ing rod of the same alloy as the parent metal is used for castings and wrought alloys. The bead is cathodic to adjoining metal, which causes minor pitting of the original metal adjacent under severe corrosion.

The tungsten electrode is very slowly alloyed with the weld metal and must be replaced periodically, but presence of tungsten does not increase the corrosion rate.

Approaches Parent Metal Strength

Dowmetal J-IH magnesium alloy, "Heliarc" welded has 95 per cent of the parent metal strength in the weld area, though the design safety factor is 75 per cent, based on butt-welded joints. Fillet, lap, edge or corner welds are weaker.

In the "Heliarc" welding process, a shield of helium gas envelops the molten metal. Because helium is an inert gas, it prevents oxidation and eliminates the use of a flux and the danger of entrapped flux in the weld ingot that would promote corrosion. The arc is produced directly between a tungsten electrode and the base metal rather than between two tungsten electrodes, as is the practice in atomic hydrogen welding.

The "Heliarc" torch is equipped with a helium valve that is opened prior to the striking of the arc between the tungsten and the parent metal, which feeds helium through the torch to the weld. When in motion, helium prevents heat accumulation around the weld, thereby keeping it cooler and giving a better fusion and penetration with less distortion than other welding processes.

Technique

The arc is struck by a light brushing action and quickly drawn back from the metal. Northrop Aircraft, Inc. has designed "Heliarc" torches, which will shortly be made available to the industry, in two sizes—to handle 1/16 to 1/8 in. electrodes and 3/16 to 1/4 in. electrodes, respectively—and may be supplied with tips of different angles 40, 60, and 90 deg. The torch may be used for pencil welding, or, by extending the handle, a handle bar grip is obtained for heavier welding. A type will later be available that feeds the filler rod automatically, giving more uniform results than where the rod is hand-fed.

Best results are obtained by feeding the filler rod into the tungsten electrode, which melts off portions of the rod, thereby cast-

(Continued on page 454)

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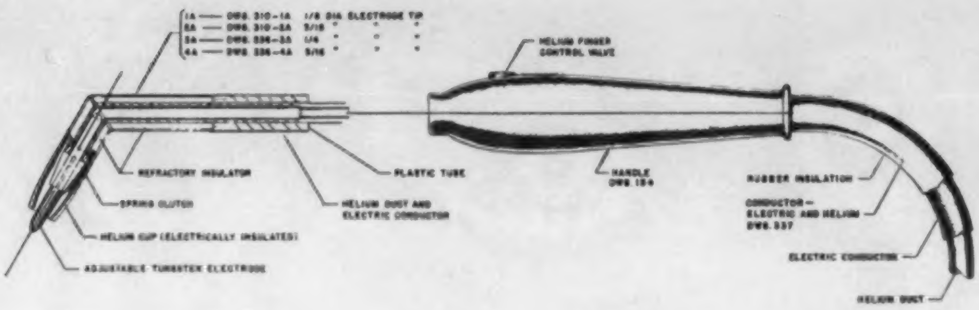
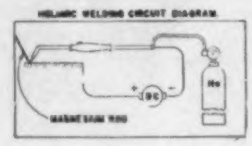




ing a uniform weld ingot. This procedure has been found to be superior to the practice of feeding the filler rod into the molten pool under the arc, whereby the molten pool is not sufficiently agitated to break the crust that gathers on the surface of the pool. Since the reflected heat from the tungsten overheats the filler rod, an angle of 60 to 90 deg. must be maintained between the filler rod and the electrode.

The tungsten electrode varies in size from 1/16 to 1/4 in., depending upon the thickness of metal welded and the heat required. The torch must be held as near the weld as possible to obtain maximum benefit from the helium for the prevention of oxidation. Also, an arc length of 0.060 in. maximum should be maintained. Poor penetration or gas holes may result by using too long an arc. On those alloys that have a tendency to be hot short, a rapid welding speed is best, say 3 ft. per minute, to eliminate the danger of cracking.

Helium Tank Life

A conventional arc welding machine with direct current generator having a 150 amp. output is desirable. However, higher output machines that operate at less than 300 amp. may be used, providing lower amperes may be obtained. An upright machine is preferable in that it is easier to attach a helium tank. Separate amperage and voltage regulators must be provided, and the machines should have a continuous sequence of five increments of current control.

The average life of a 200 cu. ft. helium tank is about 35 hrs. of continuous welding with a medium-sized torch. Fairly pure helium gas is required. Normally, helium, as purchased from the Government plant, is sufficiently pure to cause no difficulty. Additional gases in helium, such as carbon dioxide, hydrogen, nitrogen and the hydrocarbons, may cause pronounced defects. Hydrogen produces bad porosity. Oxygen films the metal, causing poor coalescence and inclusions. The presence of 7 per cent nitrogen in the helium reduces the welding speed to about two-thirds that obtained when only 2 per cent is present. All of these gases, if present, may be removed, however, by passing the helium through the filtering mediums.

This method of arc welding has provided an important new tool for the fabrication of structures from alloys, such as magnesium and stainless steel. Any type of joint that has been commonly used for welding ferrous metals may be employed on magnesium and stainless steel.

The "Heliarc" process is a result of two years of research, chiefly by V. H. Pavlecka, chief of research, and Russ Meredith, welding engineer, both of Northrop Aircraft, Inc.

● A series of lacquers especially adapted to conversion from tin and terne plate to black plate has been developed by the *Watson-Standard Co.*, Pittsburgh. They have unusual properties of adhesion to black plate and prevent underfilm corrosion, says the manufacturer. The lacquers can be made in metallic colors.

Ideal Salvage-Rubber and Copper

What might be described as ideal salvage is rubber-coated electric cable, because two of the most critical materials are recovered: Copper and rubber. *Timken Roller Bearing Co.*, Canton, Ohio, used to burn rubber and cloth insulation off cables to salvage copper.

However, to save rubber, too, they experimented with a standard Buffalo bending roll machine, which consists of three smooth wheels, two in tandem beneath a third wheel, centered above them. By raising or lowering the upper wheel, varying pressures are exerted upon the material to be bent.

Timken engineers replaced one of the lower wheels with a notched gripper wheel. The upper wheel was replaced by a sharp center-flanged wheel, the third wheel being left unchanged.

The gripper wheel feeds the cable between the flanged cutter wheel and the pressure wheel, slicing the cable open and peeling it simultaneously. The cloth cable

cover drops away from the rubber, leaving the rubber and copper in saleable condition without further treatment. Cable rubber salvaging is done at the rate of 6 ft. per min. Cables from 3/8 in. to 2 in. are handled easily. The machine is used regularly in the sheet metal department, conversion to salvaging taking only 3 min.

A more difficult salvaging problem outside the Timken shops and in the electrical industry generally, is salvaging of smaller rubber-cloth coated copper wires, smaller than cables, used chiefly on telephone lines between the street and home. Here the returned wires are kinked, with many very short pieces. Apparently no machinery has been devised to do it satisfactorily.

Tool Engineers to Train Manpower

Establishment of more adequate tool engineering training facilities in 54 war-production centers is being planned by the *American Society of Tool Engineers*. New sub-committees have been set up for training within industry, apprentice training, college curricula, vocational education, issuing of tool engineering literature and visual education.

Conversion of men not now engaged in war production and organization of tool engineering classes in colleges are objectives of one of the committees. The committee on tool engineering literature is engaged in the monumental task of reviewing the thousands of text and technical books related to tool engineering to secure proper text material for training courses.

An elaborate collection of moving pictures and slide films will be made and shown where they will do the most good.

A 300-page instructional book on "Advanced Blueprint Reading" has been added to the list of educational literature.

A war production conference of the Tool Engineer's Society has been called, to be held at the Kimball Hotel, Springfield, Mass., Oct. 16 and 17, to discuss war production problems and bottlenecks.

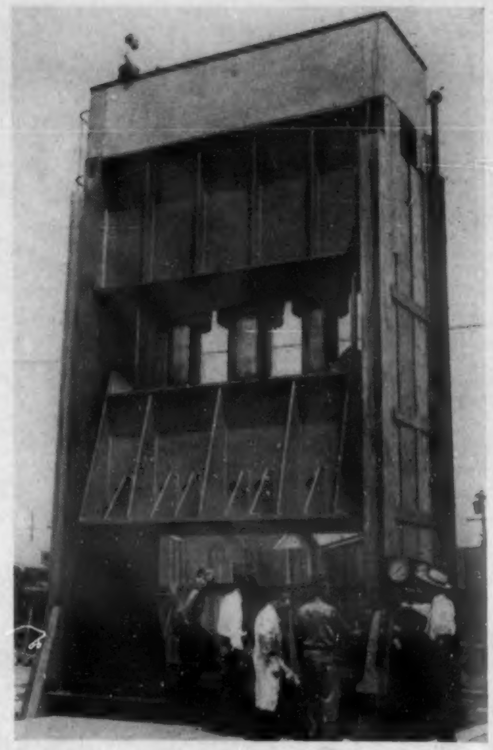
Largest Drawing Press in World

The largest drawing (die stamping) press in the world, according to its makers, is that on which 20,000 large cowl ventilators for Liberty ships are being made by the *Weber Showcase & Fixture Co., Inc.*, Los Angeles.

The machine weighs 250 tons, and can squeeze large sheets of metal into complicated sheets without tearing a corner. Two punches and dies, of hand-ground cast Meehanite iron, which form both halves of the largest ventilators, weigh 13 tons.

Unlike former presses, this embodies H-column construction, structural steel taking the place of forgings as corner posts. It is the combination of die space, air cushion arrangement, stroke and power that make this a noteworthy machine. Sheet steel may be drawn to a maximum depth of 42 in.

By changing pressures at various points around the perimeter of the bed, stresses and strains may be so governed that the sheet will not crack and tear. Rolled and welded cylinders and pistons, estimated as 4 times stronger than castings, are used. Use of the press has reduced the number of operations to ten.



Hydraulic Press & Eng. Co. secured the main contract for building the press.

Government Wants Technical Writers

Technical writers are wanted in government service. The call is for men with first-class experience in editing, writing and publicity, plus a knowledge of the steel industry, engineering, machinery, aviation, radio or allied fields. Appointees will write and edit technical articles or popularize such material for the general public. Salaries range from $2300 to $4600 per year. Those interested should contact Harold H. Leich, Administrative Examining Unit, U. S. Civil Service Commission, Washington, D. C.

New A.C. Arc Welder

An a.c. arc welder is featured by the *Hercules Electric & Mfg. Co., Inc.*, 2416 Atlantic Ave., Brooklyn. The manufacturer offers an innovation in the 3-phase solenoid field, which can be supplied for any power and stroke. One of the featured solenoids has a lifting capacity of 200 lbs. and a 3-in. stroke.

The maker points out that power costs are 50 per cent lower than consumed by welders of the rotating type, because efficiency is higher and idling losses are lower. There are no rapidly moving parts and hence maintenance costs are practically nil.

Finest silicon steel is used. Unique balanced coil construction and a revolutionary type variable core produce a splendid arc, which excels in the difficult vertical and overhead positions. It can handle steel, Monel, all forms of cast iron, wrought iron and steel.

The Joy of ORIGINATING

● Since the beginning of time, the race of man has moved through the centuries with an inward urge to improve his lot through the JOY OF ORIGINATING something new.

From flint to match, from the Stone Age to the Metal Age, from buggies and phonographs to airplanes and radios—each step in mechanical advancement has come through the JOY OF ORIGINATING.

While profit sometimes induces progress, and necessity is frequently the mother of invention, the prime urge behind the greatest scientific advances, is the sheer JOY OF ORIGINATING. Joy, in anticipation of distinction or Joy in hope of leadership.

As Horatius said, "I was the first to step out freely along a hitherto untraveled route; I have not trod in the footsteps of others; he who relies on himself, is the leader to guide the swarm."

THE *Electro Alloys* COMPANY
ELYRIA, OHIO

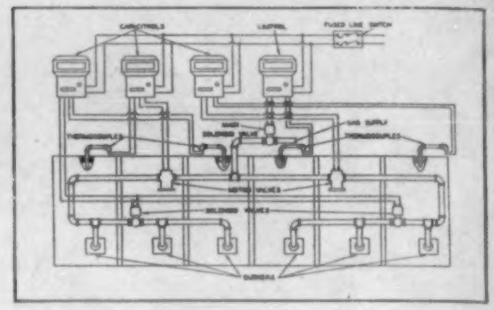
Offsetting Furnace-Door Heat Loss

A temperature control application designed to maintain even heat throughout a multiple-burner furnace or oven regardless of heat loss at the doors and to give protection against excessive temperature in case of thermocouple break or failure of control apparatus, is put out by *Wheelco Instrument Co.,* Harrison and Peoria Sts., Chicago.

Burners are controlled so that those at the extreme ends burn while those toward the center are out.

One control instrument actuates two solenoid valves ahead of the furnace's center burners. It is actuated by a thermocouple at the furnace center. Two thermocouples at respective ends of the furnace actuate two other temperature control instruments, which, in turn, operate two motor valves, the latter controlling burners at each end of the furnace. Hence, the furnace can operate at higher temperature at one end than at the other.

When starting the furnace, both motor and solenoid valves are held open. The two instruments controlling the motor valves are set at desired temperatures, while the remaining control instrument, connected to the magnetic valves ahead of the burners within the furnace, is set lower. When the furnace center comes close to the desired temperature, the third instrument closes off fuel to the center burners, leaving the end burners functioning.



X-ray Laboratory at Illinois Tech

An X-ray and radium laboratory has been completed at *Illinois Institute of Technology,* Chicago, to train experts for inspecting metals by radiography, this being the first set-up of its kind in the Middle West.

Approximately $4,000 is invested in the laboratory equipment, which was built to amplify the Engineering, Science and Management War Training program of Illinois Tech. About 18,000 persons are enrolled in various war-training courses.

A class of 25 men will be in constant training in X-ray and radium testing under Dr. Otto Zmeskal, designer of the laboratory, in a 10 weeks' course. Besides, students in other war-time branches will receive limited instruction.

The course deals with brasses and bronzes, ferrous metals of armor and battleships and the aluminum and magnesium of aircraft. Equipment includes a 200 kw. X-ray and 100 mg. of radium.

New Instrument Measures Wear

A new instrument measures precisely the amount of material removed from metallic surfaces after ordinary wear, or abrasion, grinding, honing, lapping, etc. It is the McKee wear gage, made by the *American Instrument Co.,* Silver Springs, Md. It detects wear from 0.000015 to 0.0014 in., and can make measurements on inside surface of cylinders 2-7/32 in. minimum diam., on flat surfaces, on outer surfaces of cylinders down to 1/32 in. diam., and on spheres down to ¼ in. diam.

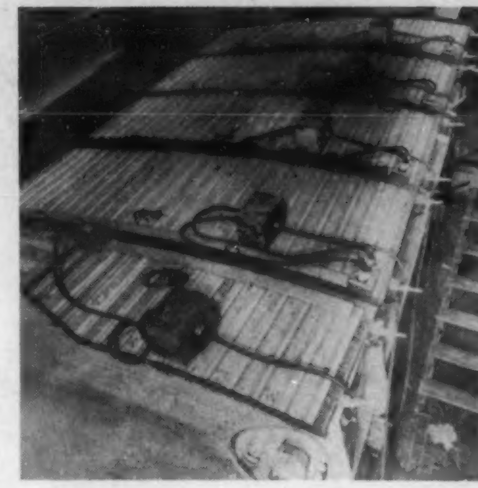
A diamond-shaped pyramidal indentation is made, whose measurements are already known. As wear takes place, the indentation becomes shorter; hence, a second measurement allows calculation of wear to be made.

For some tools it is desirable to put them out of service after a certain amount of wear. Hence, a mark of desired depth is made, and when it has disappeared, the permissible wear has taken place. The McKee wear gage consists of four parts: Indenter, measuring microscope, cylinder indentation locater and polishing template.

Taking Wrinkles Out of Aircraft Wings

In riveting aluminum "skins" over spars and ribs to make aircraft wings, wrinkling and buckling of the skins under the riveting hammers have occurred. The difficulty has been solved by expanding, then shrinking, the skin on the wing by "heat therapy" at the *Glenn L. Martin Co.* plant, Baltimore.

Sheets of aluminum that make up the skin are riveted together on a wood frame shaped like the wing. The skin, full now of unavoidable buckles and wrinkles, is laid on the actual wing. The skin heater is laid on top of the skin, the former fitting snugly because it has the exact contour of the wing. The heater, which is a glorified electric heating pad, is raised to 140 deg. F. and the wrinkles disappear. While rheostats hold the temperature constant, the skin is quickly stitch-riveted around the edges and along the ribs. The heater is removed and the skin shrinks as taut as a drum head.



The process allows a whole skin to go on in one riveting operation and speeds production. It was devised by Harry F. Kniesche, assistant factory manager at the Martin plant.

● Osborn Manufacturing Co., 5401 Hamilton Ave., Cleveland, has created an "expanded war-effort brush engineering field service." Particular attention will be given to work such as burr removal, elimination of slag and scale, and clean castings. The company claims that the speed of removing zinc chromate coating from around bolt holes in airplanes was increased ten times by power brushing over hand work.

New Plant Features Scrap Handling

Probably the latest things in layouts for new plants are efficient design and equipment for salvaging and handling scrap. Thus, a new plant for the *Kropp Forge Aviation Co.*, a new associate company of Kropp Forge Co., Chicago, has emphasis on the mechanical handling of raw materials, finished parts and scrap.

Provision has been made for the outloading of scrap directly into railroad cars for daily return to the mills of flashings, butt ends and other forging scrap.

A large number of drop hammers will be installed, ranging from 6,000 to 20,000 lbs. capacity, together with dual furnace equipment for each hammer, trimming presses and straightening or coining presses.

The plant is designed for "flo-line" production of drop forgings with crane and conveyor systems handling billets and bars from cars to heating furnaces, to hammers, to machine shop, sand blast, pickling or heat treating and inspection and on to trucks or railroad cars for out-shipping.

Capacity of the new plant will be four times the company's existing drop forging production, but because of labor-saving equipment, manpower will be two and a half times the present.

● Another product to combat the shortage of strategic alloys is "TMC High-Speed steel," which replaces 18-4-1. It is a low tungsten-molybdenum steel, equal at least to 18-4-1; is lighter and has a slightly lower hardening temperature. It is made by *Jessop Steel Co.*, 546 Green St., Washington, Pa.

News of Metallurgical Engineers

Jack M. Noy has resigned from the staff of Foote Mineral Co., Philadelphia, to become chemical engineer in the production department, Climax Molybdenum Co., Langeloth, Pa.

R. E. Powers has been named Pacific Coast district manager of the manufacturing and repair department, Westinghouse Electric & Mfg. Co., having been transferred from Chicago. Mr. Powers has been granted numerous patents on various types of electrical apparatus, including transformers, generators, relays and reactors.

Charles W. Schott has been appointed research fellow of the open-hearth committee of the Institute of Mining & Metallurgical Engineers, the department of metallurgical engineering of the University of Pittsburgh announces. He will investigate a particular steel of interest to the Army and Navy. He is regularly with the Bethlehem Steel Co.

S. R. Robinson has become works manager of the Valley Steel Casting Co., Bay City, Mich., having been foundry metallurgist for Otis Steel Works, Jones & Laughlin Steel Corp.

Robert L. Warfel, with the Carnegie-Illinois Steel Corp., Gary, Ind., has been named a research engineer on the staff of Battelle Memorial Institute, Columbus, assigned to the division of analytical chemistry.

William Seymour has become metallurgist in the Works Laboratory, General Electric Co., Bridgeport, Conn.

William E. Vogt has been elected secretary of Electro Metallurgical Sales Corp., a unit of Union Carbide & Carbon Corp. He has been with units of Union Carbide for over 30 years, and has been active with ferro-alloys, metals and other Electromet products.

Dr. F. C. Todd, formerly a member of the faculty of Pennsylvania State College, has joined the technical staff of Battelle Memorial Institute, Columbus. He holds a degree from Carnegie Institute of Technology and other institutions, is an author, and belongs to several technical societies.

Lloyd B. Kramer has transferred from Union Drawn Steel Div., Republic Steel Corp., Massillon, Ohio, to Herman Machine & Tool Co., Tallmadge, Ohio, serving as metallurgist.

Paul H. Shaeffer has resigned as assistant general manager of sales, Ohio Ferro Alloys Corp., Canton, Ohio, to accept a similar position with the Pittsburgh Metallurgical Co., Inc., Niagara Falls, N. Y.

Martin H. Schmid, manager of the Alloys Div., Republic Steel Corp., Massillon, Ohio, has been elected chairman, Armament Steels and Alloys Advisory Committee, Office of Price Administration, a committee of ten steel executives.

R. H. Langdon and *E. P. Gregory* have been appointed field engineers in the Pittsburgh and Chicago districts, respectively, by the Norton Co., Worcester, Mass. Both have had considerable experience in the research laboratories and in the sales engineering department at Worcester.

(Continued on page 466)

★ ★ ★ AND WE'LL KEEP IT FLYING!

The entire Handy & Harman organization is proud to be among the first to receive the combined Army-Navy "E" Award "for high achievement in war production."

For some time now, we have been producing silver and silver alloys for war and essential industrial uses . . . Silver for airplane bearings, silver for gun recoil mechanisms, silver for electrical contacts and silver brazing alloys for thousands of metal joining jobs in the making of ships, tanks, guns, airplanes and shells.

Our silver brazing alloys, Sil-Fos and Easy-Flo particularly, have done an outstanding job. For many months their use has been 100% for war production . . . which has multiplied many times in little more than one year.

The loyal men and women of Handy & Harman tackled this task of increasing production with a fine spirit . . . and the Army-Navy Award conferred on them testifies as to the success of their efforts.

But the battle is not over. Even greater efforts are called for . . . and will be gladly given. The entire Handy & Harman organization is determined to keep the "E" Flag flying until final victory is won.

HANDY & HARMAN
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Bridgeport, Conn. Chicago, Ill. Providence, R. I. Toronto, Canada

Harold R. Wegner has left the Syracuse Heat Treating Corp., where he was metallurgist and plant superintendent, to become metallurgist with the Saginaw Steering Gear Division, Saginaw, Mich.

Howard F. Bartels has become heat treater for Rock Island Arsenal, Rock Island, Ill., having occupied a similar position with the Illinois Tool Works, Elgin, Ill.

Raymond Ward, has become research metallurgist, General Electric Co., Pittsfield, Mass., after studies in Columbia School of Mines.

Norman Kates has become metallurgist for the Accurate Steel Treating Co., Chicago.

M. G. Jewett, formerly chief metallurgist, Chain Belt Co., Milwaukee, is now a Lieutenant-Colonel in the Army.

Edward M. Levy is now metallurgist, open-hearth control, Carnegie-Illinois Steel Corp., Gary, Ind.

● A light "Polar K" oil that completely removes perspiration, water, oil, and dirt from steel surfaces, according to the maker, has been brought out by the *Curran Corp.*, Malden, Mass. It is claimed superior to alcohol.

Meetings and Expositions

AMERICAN CHEMICAL SOCIETY, semi-annual meeting. Buffalo, N. Y. Sept. 11-17, 1942.

NATIONAL PETROLEUM ASSOCIATION, annual meeting. Atlantic City, N. J. Sept. 16-18, 1942.

ASSOCIATION OF IRON & STEEL ENGINEERS, annual convention. Pittsburgh, Pa. Sept. 22-24, 1942.

SOCIETY OF AUTOMOTIVE ENGINEERS, national tractor meeting. Milwaukee, Wis. Sept. 24-25, 1942.

TECHNICAL ASSOCIATION OF THE PULP & PAPER INDUSTRY. Boston, Mass. Sept. 29-30, 1942.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, annual meeting. Colorado Springs, Colo. Sept. 29-Oct. 2, 1942.

SOCIETY OF AUTOMOTIVE ENGINEERS, aircraft production meeting. Los Angeles, Calif. Oct. 1-3, 1942.

ELECTROCHEMICAL SOCIETY, fall meeting. Detroit, Mich. Oct. 7-10, 1942.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Inst. of Metals and Iron & Steel Divisions, Cleveland, Ohio. Oct. 12-14, 1942.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Rochester, N. Y. Oct. 12-14, 1942.

AMERICAN SOCIETY FOR METALS, annual meeting. Cleveland, Ohio. Oct. 12-16, 1942.

AMERICAN WELDING SOCIETY, annual meeting. Cleveland, Ohio. Oct. 12-16, 1942.

NATIONAL METAL CONGRESS AND EXPOSITION. Cleveland, Ohio. Oct. 12-16, 1942.

WIRE ASSOCIATION, annual meeting. Cleveland, Ohio. Oct. 12-16, 1942.

AMERICAN SOCIETY OF TOOL ENGINEERS, semi-annual meeting. Springfield, Mass. Oct. 16-17, 1942.

Plants and Slants

The Precitube Corp., 40 Wall St., New York, has completed a new factory for the manufacture of small diameter seamless tubing, especially stainless steel tubes, 18-8 austenitic steel tubes of high resistance and type 20-10, containing 2 per cent molybdenum; also, pure nickel and nickel-alloy tubes.

The Acme Steel Co., Chicago, usually sets aside $700 each year to finance the annual employees' picnic. However, employees and management voted to turn this sum over to the U. S. O. This amount was in addition to the contributions made earlier by the company and individual employees. The chairman of U. S. O. wrote back an appreciative letter, characterizing this as "an unusually generous subscription."

The Doall Co., Des Plaines, Ill., has made a further expansion of their Contour Saw Laboratory, housing this department in a building separate from the main plant. It is equipped completely from a photomicrograph and Rockwell testing equipment to a special darkroom. The laboratory solves cutting problems ...tis.

The Strippit Corp., 1200 Niagara St., Buffalo, has bought a modern building of steel and concrete at 345 Payne Ave., North Tonawanda, N. Y., where it will be located after Sept. 15th. The company manufactures self-contained punching and notching units.

A 60-day purchase option involving the *Canonsburg, Pa., Works* property of *Carnegie-Illinois Steel Corp.*, has been granted to the Defense Plant Corp. by the company. There are plans for conversion of the plant to vital war production.

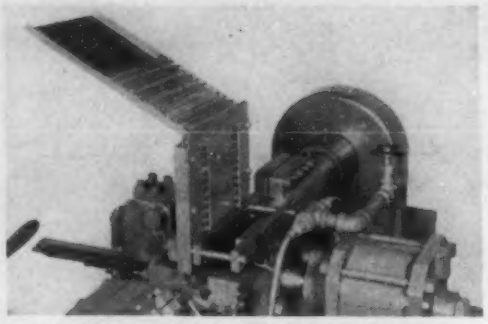
The Hays Corp., Michigan City, Ind., manufacturer of combustion instruments and control, has announced three agency appointments: Energy Control Co., for Philadelphia territory, with offices at 3107 North Broad St., Philadelphia; Engineering Products Co., 304 Davidson Bldg., Charleston, for the southern West Virginia field; Power Specialty Co., 25 North Live Oak St., Houston, for southeastern Texas.

Chute Feed Speeds Production

Production has been increased as much as 30 per cent by the addition of an automatic chute feed to the air chuck on the 2-spindle profiling machine of the *Pines Engineering Co., Inc.*, Aurora, Ill., according to the manufacturer.

This attachment is being used for feeding such items as brass and copper primer tubes for boring and tapping operations on both ends at the same time.

These profilers are being used in war work for burring, chamfering, facing, threading, centering, reaming and boring



both ends of tubes or rods simultaneously for bombs, tank tread tubes and pins, etc. Several of these operations may be combined and performed at the same time.

● In order to stimulate employees throughout the United States to originate suggestions for production, material or process short cuts, there has been formed the *National Association of Suggestion Systems.* E. S. Taylor, Director of the Employee Suggestion System of the Pullman Co., Chicago, is president.

● Electrical contacts in laminated metals are introduced by *Gibson Electric Co.*, Pittsburgh. "Gibsiloy" is used as a facing on contact surfaces, with inexpensive base metal as backing. Contacts are produced by special processing of metal powders which do not naturally alloy together.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ANNEALING
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METALLURGICAL ENGINEERING

shop notes

Air Film Doubles Stamping Output

by V. L. Greth,
Westinghouse Electric & Mfg. Co.

Not often can such simple devices as an ordinary thread spool, 2 x 2 in. cardboard and pin illustrate a mechanical principle. Actually, these trivia illustrate a device used in a punch press operation to keep pieces of aluminum from sticking in the lower die.

The application is based on the inverse relation of air pressure to velocity. It is illustrated by blowing through a wooden spool upon a piece of cardboard with a pin through it, the latter to prevent side slip. No amount of blowing can dislodge the cardboard, though gravity might be expected to cause it to drop.

The air leaving the spool at high velocity strikes the disc and escapes between the spool and the cardboard. The escaping air must overcome inertia and friction, and this causes reduced air pressure on the spool side of the disc. The result is a balance of atmospheric pressure against gravity such that the disc "floats" on a plane very close to that of the spool.

By applying this principle, stamping production is doubled and rejects cut down considerably in punch press operation at the Westinghouse Lighting Div., Cleveland. An 80-lb. air line was connected to the press and air blown through a 1/4 in. orifice drilled in the upper die. Air pressure is applied and controlled from the crankshaft simultaneously at the start of the up-stroke of the stamping motion. When the stamping operation is completed, reduced atmospheric pressure above the metal piece causes it to rise with the upper die. Air pressure is then released and the plate drops into the hands of the operator.

Pieces of aluminum, 1/4 in. thick at times, are stamped out. Formerly, it was hard to eject stamped pieces without harming the finish and slowing output. Usual methods, including vacuum cups, could not be used.

Three ways to conserve electrodes are: Make legs of fillet welds equal; don't leave more than a 2-in. stub end on each electrode; and fit all joints properly before welding (say minimum gap between parts to be joined of 3/32 in.).

—"Welding Briefs," Metal & Thermit Corp.

Chatter Eliminated by Copper Plating

by Engineering Department,
Tremont Old Colony Plating Co.

A vertical steam turbine in a power plant in the Boston area developed a bad "chatter" just when war producers were demanding more power. The shaftway running through the center of the turbine's rotating field was so worn that the field did not fit snugly on the 35-ton shaft.

It would have been complicated to cast a new rotating field or build a new shaft which was 2 ft. in diam. and 30 ft. high. However, the turbine was placed in service in 24 hrs. by one of the largest copper plating jobs ever attempted. A deposit varying from .002 to .005 in. did the trick.

(More Shop Notes on page 470)

Designing for Die Casting
Part II

by G. L. Werley & R. E. Kellers
New Jersey Zinc Co.

This is a continuation of a sketch on the above subject, which first appeared in this department, August issue. Since high production is a major advantage of die casting any design feature which affects this adversely should be avoided.

Undercuts decrease casting rates, complicate die construction, increasing costs. By eliminating them, cost savings are sometimes half the piece price. A crank handle, for manipulating an automobile door window, was first designed with an undercut near its base. It was redesigned, incorporating a contour, thereby eliminating the undercut. (See Fig. 1)

A boss in the side of a small housing originally occupied one third the wall; it was redesigned to extend to the casting's bottom, eliminating the undercut. In one case, an assembly was used rather than a single casting. The undercut was eliminated by fastening a galvanized steel clip to the die casting with a galvanized screw, this proving cheaper. (See Fig. 2)

Cores used merely to eliminate excess metal are justified only when they reduce costs without reducing strength and ease

Fig. 1

of finishing. Originally, a plate was designed with parallel troughs, making two alternate thicknesses of metal. It was designed for use of stationary cores to eliminate metal, make a uniform wall thickness and give a corrugated effect.

In another instance, a metal-saving core was justified, a design whereby two die castings can be sprung together to form a hollow handle. Movable metal-saving cores should not be used when a hardware finish is expected, since cores need lubrication, the oil impairing the casting's finish. (See Fig. 3)

Every casting must be trimmed to remove the gate and flash. Irregular edges are more difficult than plain. Thus, when

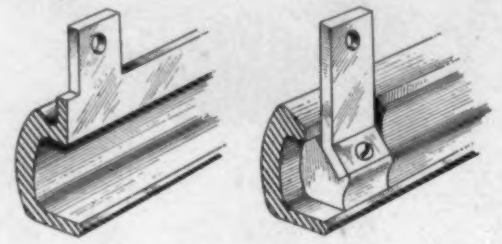


Fig. 2

an ornamental design is embossed, say on a handle, this section should fade out or stop short of the edges of the casting.

Sharp corners, a source of weakness, should be avoided through fillets. Fillets of .015 in. or even .030 in. radius are barely noticeable. On inside corners a fillet, .060 in., is common.

Drafts are necessary to eject castings from the die. Normal practice is .010 to .020 per in. draft on inside dimensions and .005 per in. on outside.

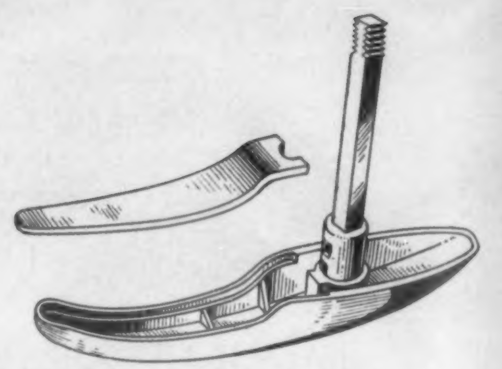


Fig. 3

Location of ejector pins to aid removal from the die is important. Where the wall is too thin, or pin marks can't be tolerated, where there are no ribs or bosses serving as ejection points, design must be altered. Often external bosses or lugs are added and later removed by trimming.

The smallest hole generally cored is 3/32 in. Smaller holes are best spotted and drilled afterwards. It is usually inadvisable to request cast internal threads, as tapping is cheaper.

It is best to make a model of a proposed die casting as it will suggest desired changes not apparent in a drawing.

When a part requires plating, all significant areas must be accessible for buffing. There should be no deep, narrow closely spaced ribs; no recesses where gas becomes entrapped; avoid sharp outside corners and points; convex shapes are better than concave or flat; rough texture patterns are hard to buff correctly.

Manganese Steel Renewal-Bushings

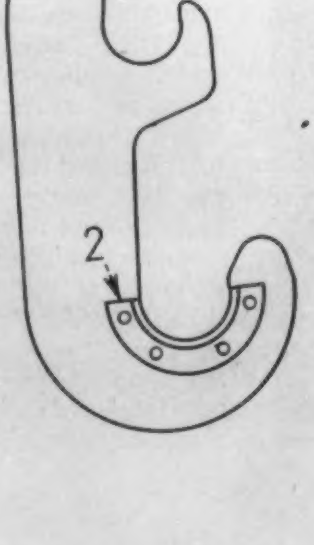
by J. I. Capps
American Manganese Steel Div.

When holes or seats are so enlarged by wear as to make the entire equipment useless, it is often possible to remedy the worn parts by installation of manganese steel bushings, either as complete circles or as half circles.

Illustrating both adaptations is a steel mill ladle hook which, at the end of the crane cable, picks up the ladle by its bail preparatory to transporting it about the mill.

The hook is usually 9 ft. long. Where either the top hole or "bight" at the lower end are unduly worn, it might be necessary to discard the entire gadget.

However, the proper size bushing is fitted into the top hole (1) and for remedying the worn bight (2) two half bushings are used, the flanges being riveted to each side and the two "barrels" meeting above.



Used in such applications is 13 per cent manganese steel, because it resists fracture under heavy stress and because the surface work-hardens under pressure and friction to an extent not equaled by other steels.

To grade cylindrically-ground surface finishes the Norton Co., Worcester, Mass., offers a set of eight finish standards. Each specimen has the Profilometer reading stamped on the end. When placed beside the job whose finish is to be judged, it affords a handy method of comparative inspection and classification. The set of specimens is packed in a mahogany case with handle, easily carried. The range of finishes will cover all cylindrical grinding jobs.

—*"Grits and Grinds,"* Norton Company.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

ADVISORY EDITORS

1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hard-facing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Design and Applications

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4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining • Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment • Melting and Manufacture of Non-Ferrous Metals and Alloys • Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces • Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice • Foundry Practice, Furnaces, Equipment and Materials

CONTENTS

High-Test Iron from the Cupola

Condensed from "Foundry Trade Journal"

For this work, actual production of high-strength iron castings was begun under carefully controlled conditions. All test-bars were poured from the ladle containing the whole bulk of the tap studied, and never from metal caught at the cupola spout. All analyses, micro-examinations, and physical tests were conducted on 1.2 in. dia. bars, poured, and allowed to cool, within standard oil-sand horizontal molds.

It was demonstrated convincingly that, in the cupola, steel scrap is not carburized to any appreciable extent until it is actually molten. That is to say, such scrap melts as steel and not as highly carburized metal of much lower melting point. Therefore, steel scrap must melt at a level considerably nearer to the zone of maximum temperature than does cast iron. When steel is melted a relatively shallow bed of incandescent coke is available for superheating.

It had been feared that the inclusion of returned high-strength iron scrap in the cupola charge would be accompanied by deterioration in the physical properties of the resultant cast iron. However, the actual results did not confirm this theory. Micro-examination revealed that increase in the proportion of return scrap charged generally produced larger graphite flakes and caused progressive interference with the regularity of the graphite pattern, but the impact values showed this trend to be associated with increased toughness, and this modification in graphite form to be a definite advantage.

The writer's own experiences in the employment of inoculation technique is described. Supplies of graphite in the form of discarded electrode, in the lump, granulated and crushed conditions, were available, and use was first made of the powdered material. Test-bars poured before and after the addition proved this to be completely successful in producing random graphite and improved resistance to impact.

In order to obtain unmistakeable proof of the effect of such additions, it was arranged to tap a low-silicon iron calculated to yield a mottled structure in the 1.2-in. dia. bar. The graphite present in the mottled bar is in the form of small interlacing deposits obviously formed from the carbide, which is a prominent constituent of the microstructure.

The inoculated bar, however, contains graphite of the normal flake type only and no free carbide is present. Such striking alteration in structure, cannot be attributed to change in composition, since the increase in carbon content accompanying inoculation was only 0.7%. Subsequent experiments proved granular and lump electrode to be successful inoculants also. The results show that inoculation by ladle addition of graphite is a perfectly practicable proposition.

Experiments were conducted in the addition of ferro-silicon in various proportions to the metal tapped from graphite-free charges. From the viewpoint of efficient inoculation, there is no virtue in excessive ladle additions of this material.

WHERE

CAN YOU

USE THIS

UNIQUE REFRACTORY?

CHARACTERISTICS

Corhart* Standard Electrocast is a high-duty aluminous refractory, manufactured by electric furnace melting and casting into finished shapes. This dense, high-melting body is especially designed for resistance to flux corrosion.

Due to its unique method of manufacture, Standard Electrocast possesses a combination of characteristics found in no other type of refractory:

POROSITY: Less than 0.5%—therefore virtually no absorption.
FUSION POINT: Cone 38 without any appreciable softening below that point.
HARDNESS: 8, Mineralogist's scale.
SPECIFIC GRAVITY: Blocks weigh approximately 183 lbs. per cu. ft.
COEFFICIENT OF EXPANSION: 0.000006 between room temperature and 900° C.
SPECIFIC HEAT: 0.25 cal. per gm. per °C. at 980° C.
THERMAL CONDUCTIVITY: 0.006 gm. cal. per °C. per sq. cm. per cm. per sec.
COMPOSITION: Standard Electrocast is of an aluminous crystalline nature.
CORROSION: Because of its low porosity and its inherent chemical make-up, Standard Electrocast is extremely resistant to corrosive action.

Most heat and electrolytic processes present spots where a better refractory material is needed in order to provide a balanced unit and reduce the expense of repeated repairs. It is for such places of severe service that we invite inquiries regarding Corhart* Electrocast as a fortifying agent to provide the balance desired.

CORHART* Electrocast was introduced fourteen years ago as an extremely high-duty refractory for the toughest portions of glass-melting furnaces. Today complete tanks built of this product are virtually standard in the glass industry.

Today, also, the metal industries are beginning to find profitable uses for Corhart* Electrocast. We do not claim that Electrocast is good for all applications. It has definite drawbacks in some kinds of service. In others, however, it is much more successful than any other kind of refractory now on the market.

The outline of characteristics on the left may tell you the whole story. If not, we would be very glad indeed to give you full information about Corhart products. Address: Corhart Refractories Co., *Incorporated*, 16th and Lee Streets, Louisville, Kentucky.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

** Not a product, but a trade-mark.*

Nevertheless, the greater the proportion of silicon added in the ladle, the more positive is the control over final composition. The disadvantage of heavy additions, however, is the appreciable cooling effect.

Other inoculating materials (calcium-silicide 1/8 in. mesh, calcium-manganese-silicon 1/8 in. mesh, silicon-manganese-zirconium 1/4 in. mesh) have been tried on a small scale. The writer favors inoculation by ferro-silicon.

—W. W. Braidwood, *Foundry Trade J.*, Vol. 67, May 14, 1942, pp. 67-71; May 21, pp. 89-94; May 28, pp. 117-120; June 4, pp. 139-142.

New German Wide Strip Mill

Condensed from "Stahl und Eisen" (Abstracted in "Sheet Metal Industries")

D. Timmermann considers that the continuous wide strip mill used in the U.S.A. is not suitable for European conditions because of the high capital expenditure and the necessity for high outputs to be economical. Attempts have been made in Europe to modify continuous rolling by joining strip from standard sheet mills by welding to enable the whole sequence of rolling down to the final thickness to be carried out in quick succession.

The disadvantages of this include difficulties with welding and fluctuating thickness.

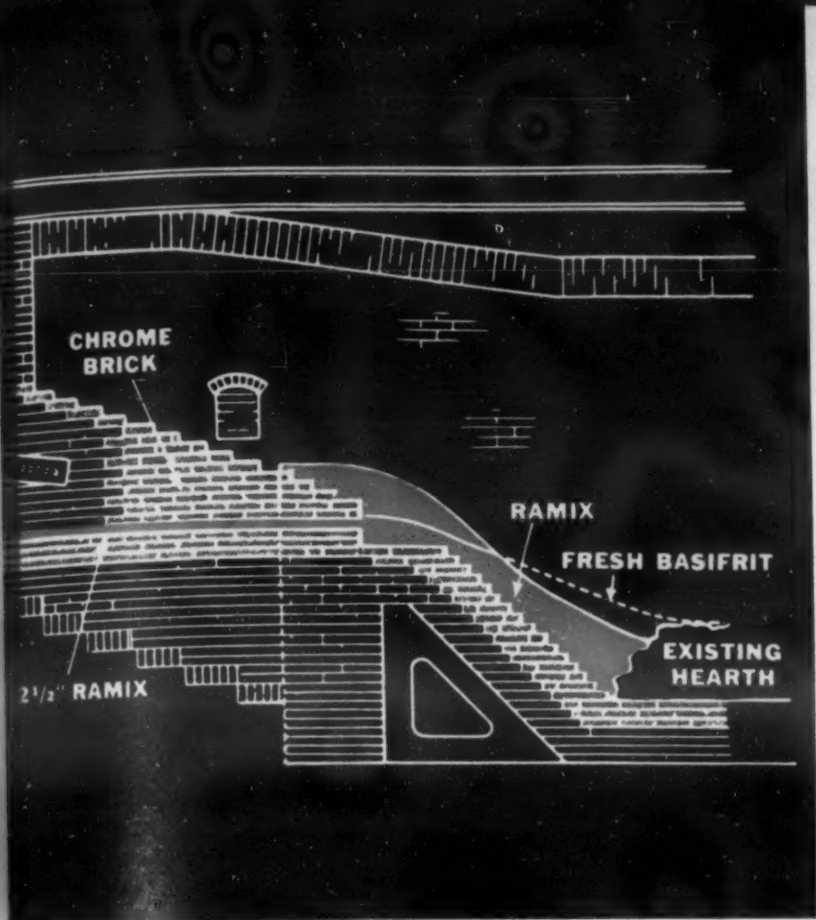
Röchling has based its development on the Broemel patents which cover basically the use of a hot coiler between each pair of stands so the strip is maintained at sufficient temperature and is not excessively cooled; the strip is coiled in the hot coiler after each intermediate pass, the direction of rotation is then reversed to feed the strip to the next stand while any heat losses of the strip are made up in the hot coiler.

Röchling now have erected a mill for handling up to 40 in. wide strip. There is a standard roughing train with four 3-high stands, with a hot coiler between each pair of stands. The strip is coiled on a heat resisting drum driven by friction rollers; the temperature of the hot coilers is kept at 1475-1650 deg. F.

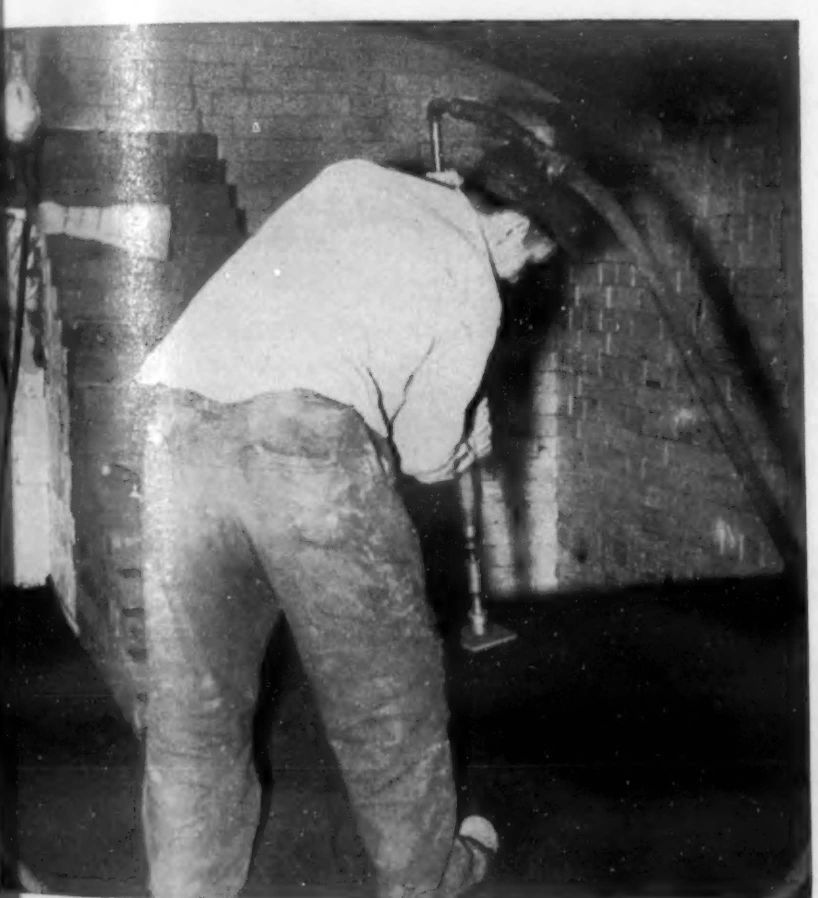
Results were so good that Röchling decided to convert two further trains to the same system, but this work was interrupted by the war. There is an indication that work is under way on a new mill using this method but equipped to roll wider strip (up to 60 in.)

The British abstractor believes from an analysis of the figures in the report that the capacity would be between 20 and 25 slabs per hour or about 50-70 tons of strip per hour depending upon the width and gage of strip. The Germans consider the Röchling method to offer advantages over the true continuous mill because a more uniform rolling temperature is maintained, speed control does not require such accurate synchronization, and it is easier to remove scale as the strip is bent several times on the coiler.

In the Röchling mill, contrary to the continuous rolling mill, the first stand is run at 11.2 ft./sec. while the second and following stand speeds are between 11.2 and 14.4 ft./sec. In a continuous mill, of course, the speed of each mill must be



Application of Ramix to port slopes of an open hearth, to protect brickwork from cutting by foamy slags. Note thin layer of Ramix carried back under burner.



Installing Ramix over port slope brickwork. With pneumatic hammer, refractory is easily and quickly rammed to desired contour. It airsets into a hard, dense monolith.

"Can you protect port slopes from slag cutting?"

was the question asked a Basic Engineer

● "What's your recommendation to prevent this?" an open hearth superintendent asked.

Trouble was that slag was going through the joints in the brickwork of the ports of an open hearth furnace, cutting out the uptakes and dropping the arches over the slag pockets. When the Basic man called, both ends of the furnace had been torn out to remove steel and permit rebricking.

His many years' experience with modern open hearth refractories enabled this Basic Engineer, a veteran open hearth man himself, to make a suggestion: "Face the slopes with Ramix." The idea seemed sound to the superintendent. They tried it, and it worked.

Ramix was installed over the new brickwork of the slopes—12" thick at the uptakes, 6" thick at the junction with the fused hearth. It was well rammed to provide an even, properly-shaped contour. A 2½" layer of Ramix was carried back under the burner, between the burner wing walls. The first heat charged was a skull heat and developed the usual foamy slag. Slag washed up into the port slopes, cutting the sidewall brickwork, but the Ramix stood up. And today, after two years of severe wartime service, the Ramix slopes are still sound.

The service that Basic Engineers give is practical. It may help you get more production out of your furnaces. Think of these men as *your* Refractories Service Men and call on them whenever you have a refractory job to do.

MAGNEFER—Dead-burned dolomite for hearth and slag line maintenance.

SYNDOLAG—Dead-burned, rice size dolomite for maintenance.

BASIFRIT—Quick-setting magnesia refractory for new construction, resurfacing and maintenance.

OHIO MAGNESITE—Domestic dead-burned high-magnesia grain refractory, equal to Austrian.

695 PLASTIC—Strong plastic basic refractory for hot and cold repairs.

RAMIX—An air-setting, time-saving basic refractory for rammed hearths and cold repairs in open hearth and electric furnaces.

GUNMIX—A basic refractory with chemical bond, sized for use with a cement gun.

HEARTH PATCH—For deep hole patching and other quick repairs in the basic open hearth.

RAW DOLOMITE—Washed open hearth dolomite in rice size and standard ⅝-inch.

BASIC HEARTH
REFRACTORIES

BASIC REFRACTORIES INCORPORATED

FORMERLY BASIC DOLOMITE, INC.

CLEVELAND, OHIO

considerably greater than or the previous mills to take care of the greater length of strip.

The English abstractor feels this solution is only a "rather complex adaptation of the principle of the semi-continuous mill."

—*Sheet Metal Ind.*, Vol. 16, July 1942, pp. 965-966.

War Material Production in India

Condensed from "Army Ordnance"

Munitions manufacture in India was in progress as long ago as 1801. Dependable items for war have been made during the intervening years. Since the present war started very impressive gains have been made, both from standpoint of total volume of munitions produced and number of additional items manufactured.

Thus a large variety of new types of special steels are now being manufactured in addition to the standard structurals, rails, galvanized sheets and carbon steels. Among these are: Special bar for shells, bullet-proof armor for vehicles, bullet-proof howitzer shields and gun turrets, alloy steels for helmets, armor-piercing bullets and shot, blades for shearing armor plate, chromium-molybdenum steel for aircraft, springs for machine guns, deep-drawing steels for rifles and machine-gun magazines, nickel steel plates for gun carriage mountings, high-carbon steels for high-explosive shells and dies, high-speed steel for machine tools, stainless steel for surgical instruments.

Among other manufactures are steel-mill rolls, wire rods for drawing into telegraph wires and barbed wire, Admiralty steel for shipbuilding. Acid open-hearth steel for gun forgings, axles, railway wheels and tires, has been developed. At one ordnance factory a record production of tungsten high-speed tool steel has been achieved.

An aluminum rolling mill started-up in December, 1940, while a plant to refine alumina nears completion. Extruded lead pipes, rolled lead sheets and brass ingots are other products. Refining of antimony is well along and efforts are being made to develop zinc, magnesite and manganese.

Chrome products are a "natural" for India because of large quantities of native ore. The development of stainless steel containing 30 per cent chromium has been a Godsend.

By the middle of 1941 India was making five times as many guns a year as in peacetime. The first aircraft to be assembled in India was completed in July, 1941, designed in the United States and modern throughout. A program for construction of many and various types of naval vessels was initiated at the end of 1940.

Among the types of ordnance produced successfully are: Various types and calibers of shell, small arms ammunition, pyrotechnics, grenades, complete guns and carriages of several types, rifles, bayonets and light machine guns. More varieties are being planned.

Centers of armament manufacture are Cossipore (five miles from Calcutta) and Ishapore.

—S. J. Hopper, *Army Ordnance*, Vol. 23, July-August, 1942, pp. 82-87.

Salvage in the Brass Foundry

Condensed from "Metal Industry"

A system of scrap salvage employed in British copper and brass foundries, which recovers 99.5 per cent of the metal from residues and shows a "handsome return" where metal content of residue is 10 per cent or better, is similar to that for concentrating ore at or near the mines.

Apparatus consists essentially of a jaw crusher for the larger pieces, a ball mill for the smaller pieces and the well-known Wilfley tables with riffles which separate by gravity the heavier metal particles from the waste.

Adjuncts are of course conveyors, running water and shaking action of the Wilfley tables. The sequence of the process is as follows: The waste mixture of copper, brass, sand, slag, skimmings, cores, coke, etc. is placed on the grizzley screen.

What fails to pass through the screen is ground up in an adjoining jaw crusher, then screened. A conveyor carries these screenings to a ball mill which discharges all material except 2 inch or larger pieces of metal which are removed at the time of periodical cleansing and are ready for remelting. The ball mill discharges on to the trommel screen the ground-up mixture direct upon the Wilfley concentrating table, which is so familiar to mining and refining men.

The riffles (or slats) are set diagonally and over them are flushed with water the mixture of metals and waste. The metal particles, having a higher specific gravity than the waste, gravitate to the diagonal line at which the riffles terminate and discharge over the end of the deck into collecting boxes. The lighter materials with the water flow over the riffles and discharge over the side of the deck into a trough or tailings launder.

Thus, metal is recovered at three points of the process: (1) In the ball mill body, pieces ½ to 2 in. cube; (2) oversize on the trommel screen, 30 mesh to ½ in.; (3) Wilfley table as concentrate below 30 mesh.

Further refinements have to do with water recovery, either by settling tanks or filtering, the former being less expensive. There are also alternate methods of disposing of the sand, etc.

—L. Readman, *Metal Industry*, June 12, 1942, pp. 396-398.

Producing Ferro-Alloys in Sweden

Condensed from "Jernkontorets Annaler"

The authors discuss production of the common ferro alloys and the following metals: aluminum, magnesium, zinc, lead, copper, nickel, cobalt, and tin, with main emphasis on Swedish conditions, and give Swedish production statistics.

In modern electric-furnace design, the electrode arrangement presents greater problems than the construction of the furnace itself. Furnaces of 10,000 to 15,000 kw. capacity are quite common, and units up to 25,000 kw. are in operation. This means loads as high as 350,000 amps. per electrode.

The introduction of Söderberg electrodes has meant a great step forward in ferro alloy production. The important advantages offered by Söderberg electrodes are:

(1) Lower initial cost
(2) Reduced electrode consumption
(3) No stoppage for changing electrodes. This means uninterrupted furnace campaigns, increased production, and smaller furnace crews.
(4) Increased furnace capacity

Söderberg electrodes may be used for current densities up to nearly 100 amps. per sq. in., about 3 times greater than those used with ordinary carbon electrodes. Electrodes measuring up to 8 ft. in diameter are used. While in 3-phase furnaces ordinary carbon electrodes are generally placed in a straight row, to facilitate changing, Söderberg electrodes are usually arranged in a triangle, giving more symmetrical distribution of the current and permitting a cylindrical furnace construction with maximum stability.

The article also discusses the recovery of vanadium from iron ore, and gives details of the process which has been used for several years at Christiania Spigerverk, Oslo, Norway. Pig iron is produced in a Hole-Tysland electric arc furnace (described in *Jernkontorets Annaler*, Vol. 119, 1934, p. 81) using a magnetite concentrate from Rödsand mine of the following analysis: 63 Fe, 0.5 V, 1.5 Ti, 0.03 per cent P.

The pig iron is given a preliminary blow in an acid Bessemer, and finished in

an electric steel furnace. Vanadium is concentrated in the Bessemer slag. *The analysis of the iron* is given in the Table.

	C	Si	Mn	P	S	V	Ti
Before blowing	4.0	0.3-0.6	0.2	0.02	0.015	0.65-0.70	0.3-0.5
After blowing	1.5-2.0	0	0	0.02	0.015	0.02	0

The analysis of the Bessemer slag is: 10-12% V, 30-35% SiO_2, 3.0-4.5% MnO, 8-12% TiO_2, 30-40% FeO.

The recovery of vanadium is as follows:

Ore to pig iron	about 80%
Pig iron to bessemer slag	" 90%
Overall—ore to slag	" 72%

At Domnarfvet, Sweden, a pig iron containing 0.2% V is produced. In tapping this iron a calculated amount of iron concentrate or finely crushed sinter is added in the runner, forming a high-vanadium slag, which is charged to a special blast furnace. This furnace is also charged with high grade sinter and with slag from the early stages in the blow of a Thomas converter, which runs high in vanadium.

By this procedure a pig iron with about three times the vanadium content of the original is produced. This iron is then blown in a special Bessemer, with addition of mill scale, producing a slag with 10-11% V.

The high-vanadium slag is generally treated by chemical methods to produce pure oxide. It is first subjected to a chloridizing roast, followed by leaching, whereby the vanadium is recovered as a sodium vanadate solution, from which vanadic acid is precipitated by neutralization.

Where the phosphorus content is not too high, it has also been found possible to produce vanadium alloy steel with up to 0.2% V by direct addition of the high-vanadium slag to an electric furnace charge.

—Bo Kalling & Axel Lindblad
Jernkontorets Ann., Vol. 125, No. 8, 1941, pp. 333-422.

Basic Open-Hearth Refractories

Condensed from "Proceedings," Open Hearth Conference

One of the features of the A.I.M.E. Open Hearth Conference this spring was a session on basic open hearth refractories, at which useful information was presented on rammed monolithic bottoms, artificial magnesite bottom-repair materials, chrome ores and substitutes, etc.

Bottoms—Rammed and Otherwise

H. M. Griffith (Steel Co. of Canada) reported another successful installation and operation of a Ramix bottom in place of regular magnesite. Placed in a 200-ton furnace, the depth of the Ramix was 16 in. The cost of the Ramix bottom is higher than that of regular magnesite, but fuel and labor savings offset this and time savings have in addition been considerable.

KN, another rammed material, also was the subject of favorable operating reports from steel men. There seemed to be little difference in performance between the two materials.

Some operators use 3 in. of magnesite or double burnt dolomite in the Ramix bottoms, while others used the Ramix alone, with no conclusive differences in performance apparent as yet.

J. J. Golden of Gary Works has completely or partially replaced over 10 bottoms in the past 2 years, using either Ramix or KN with a relatively shallow layer of sintered material on the top. The monolithic sub-bottom definitely gives better service and longer life, and if generally applied, could increase overall open hearth capacity by 2-3 per cent, he believes.

H. N. Barrett, Jr. of Basic Refractories, Inc., described several typical applications of Ramix. Among the ramming practices that increase the savings available with rammed bottom repairs are the use of wooden forms to shape the banks—this speeds the installation, lightens the manual labor and gives a more uniform shape and denser structure.

Also, a special ramming of the juncture of the banks and flat and preliminary roughening of the flat are carried out to assure a good bond between banks and bottom. There seems to be some merit, too,

in carrying the bank higher up the back wall than the sill level.

It has been found that the introduction of ramming material through the front of the furnace is less satisfactory than introducing the Ramix through the back wall. Also, it is better to run the forms the entire length of the furnace than to run them half-length.

The trend in open hearth rammed-bottom construction is to increase the ratio of Ramix thickness to "burned-in" working hearth depth. Steel of all types is now being made directly (*i.e.* with a "working hearth" of magnesite) on Ramix hearths in more than 100 electric furnaces in North America. The furnace sizes range from 200-lbs. to 80-100 tons.

Barrett believes the increasing use of rammed refractory construction may lead to a new conception of the functions of steel furnace hearth components. A bottom may be considered to comprise 3 divisions —a subhearth (pan, insulation and brick), a permanent hearth (the monolithic rammed portion), and a replenishable hearth (the burned-in section of granular refractory). The replenishable hearth is the working hearth, and would be systematically renewed to protect the permanent hearth and keep bottom trouble at a minimum.

I. A. Nicholas of Standard Lime & Stone Co. described Sta-Set, an artificial magnesite used for making new bottoms. Made from dolomite by removing much of the lime and adding ferric oxide before roasting, this material contains 4 per cent silica, 10 total iron as oxide, 2 alumina, 14 lime and 70 magnesia.

Sta-Set can be burned-in at normal operating temperatures without using an auxiliary flux. The material is quick-setting, especially in fine grain sizes.

Several operators testified to the efficacy of this material for general bottom patching, paying tribute to the speed with which patches can be made and durability of the patch in furnace operation.

Chrome Ores

Finer grinding of chrome ores (according to F. L. Toy of Carnegie-Illinois) will assist greatly in getting plasticity of chrome ores, but it may be necessary to add a plasticizer such as shale. In general, a fineness of —8 mesh is required.

The grinding of chrome ore by the open hearth operator himself is usually not fine enough. Experience has indicated that a balanced chrome-ore mixture, sufficiently fine and with the right binder, that will coke and hold the ore together long enough to let it sinter, as purchased from any good refractory-manufacturing company has easily paid for the extra cost entailed.

Some operators successfully substitute olivine for a part of the chrome ore, carrying also magnesite in the mixture. One speaker also favors the addition of bentonite (2.5 to 3 per cent) to chrome ore mixtures.

In another case, chrome ore is being saved by using double-burnt dolomite (80 per cent) mixed with tar or heavy oil, the mixture containing 20 per cent open hearth slag as well. This is shoveled onto the back wall, usually when the furnace is working lime or between drags of scrap. Results are economical and entirely satisfactory.

Roof temperature control was discussed. In general, it seems to have increased roof life by several heats (25 in one case), or to have permitted increased hourly tonnage or to have allowed better gasification rate at the producers. Some men reported that misuse of the system by operators caused lengthening of heating time, and some drop in operating efficiency.

Furnace Repairs

To speed up furnace repairs, one company now uses rib brick 6 in. longer than the roof brick, instead of rib brick 3 in. longer than the roof brick. Another installed soot blowers in the flues, and extended roof life 50 heats while maintaining constant tons-per-hr. production.

Open-end construction may provide longer roof life through the increase in uptake area it permits. Basic refractories are finding wider applications on end panels, dog-houses, bridges and front walls to achieve better-balanced furnace-part life.

Metalkase brick are employed in one mill to reduce the number of delays. Conveyors are increasing in use to move brick from the pit to all parts of the furnace.

Suspend roof construction is discussed by J. A. Clauss of Great Lakes Steel

Corp. The cost of suspended-arch brick is at least three times that of a straight silica-brick roof. In one design, there are 6 castings in the length of arc, and any one can be removed without disturbing the others.

Monolithic rammed doors were favorably reported on. Experience with ladle wells was also described; using a nozzle cap brick, or burned insert well, one operator achieved considerable saving in gas without loss of any heats through the metal cutting through around the nozzle. Another company has had good results with burned pocket blocks in replacing rammed wells.

—*Proceedings*, A.I.M.E. Open Hearth Conference, Vol. 25, 1942, pp. 50-88.

Refining Pig Iron in the Electric Furnace

Condensed from "Jernkontorets Annaler"

The practice of refining pig iron in the electric furnace has been used at Wikmanshyttan, Sweden, since 1928. An electric arc furnace of the Heroult type, of 6.5 tons capacity is used, and they have been able to increase the capacity to a charge of over 11 tons, producing over 10.5 tons of ingots per heat.

As special steels are generally produced, 2 slags are used, first an oxidizing slag, which is skimmed off, next a reducing (white) slag made just before tapping the heat. An analysis is made after the first slag has been skimmed, to permit adjustments in the final composition.

The furnace has a basic lining and silica roof through which three 8-in. graphite electrodes are introduced. Maximum load used is about 1700 kw.

In charging about 2/3 of the scrap is placed on the bottom of the furnace, followed by 450 lbs. of dry concentrate with about 68% Fe; 330 lbs. lime stone is placed on top of the concentrate and then the last of the scrap. About 4-½ tons of hot metal is charged, and full power is put on.

After 1-½ to 2 hrs. the carbon content of the bath is down to 0.10 to 0.20%. About 3.3 tons of hot metal is added, and in 15 to 30 min. the bath is up to full reaction temperature, so that the carbon content can again be brought down to 0.10-0.20% through careful addition of ore.

When the desired carbon content is attained, the oxidizing slag is skimmed off, and a new, reducing slag is made up in regular manner. Samples are taken for analysis, and the required amounts of alloy are added. From this point, the procedure is the same as in ordinary electric steel production.

The pig iron used should be low in silicon and manganese, 0.3 percent or lower. As the furnace atmosphere is only slightly oxidizing, compared with that of an open hearth furnace, there is no danger in holding down silicon and manganese in the hot metal.

At times when no hot metal is available the furnace is charged with cold pig, half of which is used in granulated form. In this case all the pig is added at one time. The pig, scrap, concentrate and limestone are placed in the furnace first, in alternate layers, and the granulated pig iron is placed on top.

The results of 14 heats, producing chromium steel with 1.0% C and 1.5% Cr, are given in the Table.

	Lbs.	Per Cent of Ingot Weights
Hot metal	199,892	69.8
Cold pig	2,563	0.9
Scrap (1% C)	61,600	21.5
Concentrate 36,960 lbs., Fe contained	25,080	8.7
Lump ore 6,710 lbs., Fe contained	4,180	1.5
Limestone 16,620 lbs	7,759	2.7
Alloys		
Total Iron in charge	301,074	105.1

Kw. hrs. per ton of ingot	553
Graphite electrodes per ton ingots	8.45 lbs.
Average time per heat	5 hrs. 23 min.
Metal charged per heat	21,505 lbs.
Good ingots produced	284,152 lbs.
Scrap produced	2,200 lbs.
Total metal produced	286,352 lbs.
Iron slagged	14,722 lbs.
Ingots produced per hour	3,784 lbs.
Average Analysis of Pig Iron	C 4.2% Si 0.4% Mn 0.3%

—Edvard Berg, *Jernkontorets Ann.*, Vol. 125, 1941, No. 8, pp. 423-440.

Processing and Fabrication 2

FORGING, FORMING, MACHINING
HEAT TREATMENT, WELDING, FINISHING

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining • Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering • Heating Furnaces, Refractories, Fuels and Auxiliaries • Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting • Cleaning, Polishing, Buffing, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing • Die Casting • Powder Metallurgy

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Dry Machining of Magnesium

Condensed from "The Iron Age"

Study of British and American practice in machining magnesium alloys reveals a marked difference. American production engineers frequently employ a liquid coolant designed to maintain the tool and work temperature below the ignition point and quench sparks that might otherwise be expected to ignite the finely divided metal.

The practice of dry machining magnesium alloys is universal in England except in a very few instances, and a definite trend in this direction is developing in the United States today. Dry machining enables the operator to take full advantage of the excellent machinability of the metal and, equally important, realize far greater X-ray value from clean, oil-free chips due to the higher recovery obtainable in melting.

Owing to the free cutting qualities of magnesium alloys, the higher the cutting speed, the better the results. The low-cutting pressure required and the high thermal conductivity of the metal results in a rapid dissipation of the heat generated by the cut and prevents overheating of the cutting tools. The use of maximum cutting speeds permits marked reduction in machining time.

In general, it may be said that wherever possible high speed tools should be used for machining magnesium alloys, or, if such tools are not to be had, those available should at least be operated at maximum speeds.

All tools in action on magnesium alloys must in every case be taking off a definite cut. It is most inadvisable to "take a skim" or merely dust the surface, since this is likely to cause a spark which may ignite the loose swarf. This risk is also present if a cutting edge is dragging, that is, if the rear of the blade or cutter makes contact with the work behind the cutting edge of the cutter.

In English practice, all possible measures are taken to allow converging chips freedom to disperse by providing adequate chip room and by polishing the drill flutes and top rakes of cutting edges. Extreme care is exercised to insure that the cutting edges of all tools are kept sharp and keen at the point of contact with the work. If they are in the least blunt, or even slightly damaged, not only will the machined surface be rough, but considerable heat will be generated.

On certain automatic lathes the part being machined and the tools employed are too small for the heat to be rapidly conducted away at the high cutting speeds. Cooling is required in such cases, and it has been found necessary occasionally to resort to a liquid coolant. In the majority of cases where a coolant is indicated, however, compressed air has been found entirely adequate.

A type of twist drill has been developed in England and found to be entirely satisfactory. The body diameter has as little land as possible (0.015 in.) and the flutes are as wide and open as the strength of the drill will allow and always well polished. Care is taken not to have the flutes too "slow" (helix angle too steep)

SUPER-CYCLONE PERFORMANCE SHEET NO. 57

COMPANY [redacted]

STREET [redacted] CITY [redacted]

EQUIPMENT

TYPE OF FURNACE 3336-GHV SERIAL NO. H-4294

FLOOR SPACE 80" x 110" (61.1 SQUARE FEET)

CHARGE

WEIGHT OF PART 4.5 LBS.

NO. OF PIECES 328

THICKEST SECTION 1 1/8"

TYPE OF METAL ND-3250

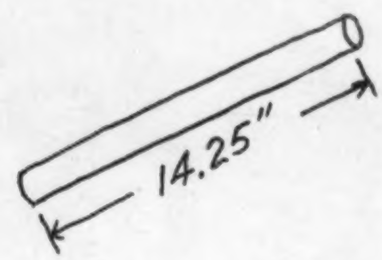
CHARGE GROSS LBS. 1876

CHARGE NET LBS. 1476

WEIGHT OF FIXTURE 200 (2)

HANDLING TIME (LOADING) 18 MIN. (UNLOADING) 8 MIN.

[DIMENSIONS, SKETCH AND DESCRIPTION OF PART]



HEAT TREATMENT

PROCESS HARDENING TEMPERATURE 1525° F.

TIME IN FURNACE 1 HR.-45 MIN. TIME TO REACH HEAT 45 MIN.

TYPE OF QUENCH OIL TANK SIZE 5' DIA-6' DP. GALS. PER MIN. 1100 QUENCH 50 COOLING

DISTORTION 90%-.002"-.003" 10%-.010" MAX. HARDNESS BEFORE TEMPER 56-58 R.C. AFTER 37-39 R.C.

TEMPERING

FURNACE 2536-GH SERIAL NO. T-4295 TEMPERATURE 950° F.

TIME IN FURNACE 80 MIN. TIME TO REACH HEAT 20 MIN.

PREVIOUS METHOD OF HANDLING NONE

FURNACE SERIAL NO. TEMPERATURE

TIME IN FURNACE TIME TO REACH HEAT

HANDLING TIME (LOADING) (UNLOADING)

DISTORTION FLOOR SPACE

DATE 8-10-42 INVESTIGATOR R. S. AITCHISON

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HYDRYZING FOR SCALE-FREE AND DECARB-FREE HARDENING

or the drill will run out of line, especially if not ground correctly.

Owing to the quick cutting action, the swarf forms up the flutes in large quantities, and a blocked drill results if the flutes are narrow, small or unpolished. Cutting edges must be kept clean.

They must cut dry and as fast as the drill permits without heating up. If the drill is allowed to get dull, the result is a hole that is too small and a swelling develops on the starting point of operation.

Similar principles apply to reaming, milling, tapping, boring, turning, etc. In sawing, bandsaws made of a special self hardening steel are usually recommended in English practice. A 1¼-in. blade with 5 teeth per in. is operated at a peripheral speed of approximately 5300 ft. per min.

English practice is to dry grind almost exclusively, whereas wet grinding is quite frequently used in Germany. For dry grinding, special equipment has been developed to quench the dust immediately it leaves the grinding wheel.

In the type of equipment most widely used, the dust is exhausted at the grinding point and immediately passes through a spray of water from several nozzles. This air-dust-water mixture is conveyed through a pipe to the separator outside the building, where the dust and water descend to the sludge pit which they enter below the water level.

The controls of the exhaust equipment are so correlated with the grinder that the latter cannot be started until fan and water spray are operating, and will stop if for any reason the exhaust suction should cease.

For polishing operations, sand paper, not emery paper is customarily used. The part is oiled after polishing.

—H. Mills Garner, *The Iron Age*, Vol. 150, July 23, 1942, pp. 52-54.

High Test Iron for Dies

Condensed from "Western Machinery & Steel World"

High test cast irons may be divided into three classes: (1) Alloy cast irons; (2) heat treated cast irons; (3) special-process irons, such as Meehanite and Nitensyl.

Meehanite shell nosing dies have given a yield of over 3700 shells (die refinished 3 times) in hot nosing shells where the ejection system is used on the press. In comparison, previous cast dies gave a total life of 18 shells and alloy steel dies, 333 shells (no analyses given). Meehanite shell draw rings are similarly providing satisfactory service.

Extensive use is being made in the aircraft industry of cast Meehanite dies for stamping aluminum body parts, stainless steel exhaust collector rings, etc. Meehanite is likewise being used for dies for forging 40-lb. aero bombs and for shell punching dies.

Other types of application include British army tank brake drums, diesel engine castings such as crankshafts, tool shanks for sintered carbide tools, etc.

—O. Smalley, *West. Mach. & Steel World*, Vol. 33, July 1942, pp. 314-317.

Rectifiers for Electroplating

Condensed from a paper for The Electrochemical Society

Direct current equipment installed and on order by American electrochemical industries has increased fourfold from 890,000 kw. in 1938 to approximately 3,500,000 kw. at present. New aluminum and magnesium plants utilizing mercury-arc rectifiers operating at 600 volts and higher are principally responsible for this rapid and tremendous growth. Mercury-arc rectifiers now predominate over motor generators and synchronous converters in amount of capacity installed.

Plate-type rectifiers are being used for electroplating but are unsatisfactory for large-scale electrolytic work. Each type of conversion device has individual characteristics that render it more favorable than others for a given installation. Engineering comparison and economic evaluation of all factors involved are imperative to selecting the best type of equipment for specific applications.

In large scale electrolytic work three types of conversion equipment, namely, motor generators, synchronous converters, and mercury-arc rectifiers have proven very satisfactory. In electroplating and electrogalvanizing operations where smaller quantities of power are generally consumed but where high amperage and low voltages are required, motor generator sets and, more recently, plate-type rectifiers have proven satisfactory.

During the past ten years mercury-arc rectifiers gained favor over rotating conversion equipment, particularly for operating voltages above 500 volts. The development and application of these devices represents an epoch or milestone in the electrochemical industry. It is not unreasonable to expect further improvements and developments beneficial to the industry resulting from manufacturing technique and operating experience obtained on recent large installations.

The application of mercury-arc rectifiers to electrochemical production has been principally responsible for a decided upward trend in cell room operating voltages. In at least one plant, rectifiers were initially installed to operate in parallel with synchronous converters and motor generators at low voltage from 250 to 300 volts, and later changed readily and economically for double voltage operation at 500 to 600 volts and with twice the original capacity when plant expansions were necessary.

Information at hand indicates that some cell rooms in the United States are operating at potentials up to 625 volts, and it is significant that one installation in this country is reported equipped with rectifiers capable of supplying power up to 1,000 volts.

The growing use of plate-type rectifiers for electroplating makes of interest the following comments on their advantages and drawbacks.

Advantages—Being a static device and light in weight, maintenance costs and installation costs are low. Efficiency at low loads is considerably better than motor-

generator sets. Full load efficiency persists down to 25% of full load. No-load or light-load power losses are very small as compared to motor generators.

Plate-type rectifiers are extremely simple in construction and operation. They can be turned "on" and "off" by a simple contactor, push button operated, and do not require any special starting devices.

Disadvantages—Maximum efficiency is not as high as that of motor generators, and there is some loss in efficiency (about 2 to 5%) with age. Regulation or drop in voltage from no load to full load is quite high, being about 85% for 6-volt operation and greater at lower loads. Voltage regulation increases with age.

Plate-type rectifiers cost about 15 to 20% more than motor generators of the same capacity; for example, 10,000 amp., 12 volt, 120 kw. plate-type rectifiers range in cost from $165 to $180 per kw. compared with $140 to $155 per kw. for motor generators of the same capacity. The rectifiers also require ventilation and fans for circulating air; air must be clean, dry, and noncorrosive.

—L. H. Fletemeyer, *Electrochemical Society*, Vol. 81, 1942, Preprint No. 32

Brazing of Small Assemblies

Condensed from "Sheet Metal Industries"

Torch brazing is most generally used and requires the least equipment. The gas mixture depends on the job (especially thermal conductivity of the metal being brazed), but a slightly oxidizing flame should be used to guard against gas unsoundness of the joint. Paste flux is usually more economical than dry powder flux and ensures adequate fluxing.

The parts should be cleaned (type of cleaning depends on alloy or metal being brazed) and degreased before brazing. Often cleaning can be done more easily mechanically (*i.e.* filing, grinding, or sand blasting) than chemically (pickling). Preheating saves time on the brazing bench if there is considerable mass involved.

Furnace brazing is suited to large scale production of small pressed or turned parts which must be brazed. Copper brazing of mild steel assemblies is typical. The furnace always has a reducing atmosphere and is usually of the conveyor or pusher type. Bottled hydrogen is an efficient atmosphere if pure, but costly and explosive.

Cracked ammonia is efficient but also explosive. Cracked and burnt ammonia is considerably cheaper and non-explosive. Burnt coal gas is often the cheapest reducing atmosphere available and is non-explosive. No flux is required, because of the reducing atmosphere. Decarburization must be taken into consideration if high-carbon steels are being copper-brazed.

Furnace brazing can also be used with silver alloys for both ferrous and nonferrous alloys. If the brazing alloy is silver-copper-zinc or silver-copper-zinc-cadmium, the furnaces are similar to those used for copper brazing, but generally a reducing atmosphere is not necessary and even the use of a controlled atmosphere

does not necessarily eliminate the necessity for fluxing.

If copper and copper-rich alloys are being brazed, silver-copper-phosphorus brazes may be used. These brazes have the advantage of being capable of use without flux and without a controlled atmosphere. Flux residuals that may set up subsequent corrosion must be removed from the work by pickling or washing after brazing.

Electric resistance brazing involves the application of heat only to the immediate locality of the joint. Special machines are generally required, as well as close control of current. Little work has been done in this field so there are few general rules, but it has proven valuable where it is necessary to braze a cold worked component without tempering the hardness any more than the minimum possible. Induction brazing is also growing in use.

Dip brazing (immersion of the joint for a short period in a bath of molten brazing alloy covered with molten flux) is used in England only for manufacture of steam turbines (brass or silver brazing alloys are used depending upon the composition of the blade) and bicycles (brass brazing alloy).

Salt bath brazing is conducted in U.S.A. but has not been widely used in England. The fused salt employed is one which is capable of acting as a flux in addition to protecting the work and the brazing alloy and acting as the heating medium. Forge brazing is conducted similarly to torch brazing.

—H. R. Brooker, *Sheet Metal Ind.*, Vol. 16, June 1942, pp. 843-853.

Induction Heat for Aircraft Work

Condensed from "Aviation"

Induction heating has been introduced successfully to internal hardening of aircraft engine cylinders; to the hardening of gears where physical properties of the root of each tooth must not be disturbed or weakened; and to brazing aircraft wiring harness assemblies, spark plugs and magnetos. Experiments are being conducted on many other phases of aircraft work.

The principle of induction heating is not new. Yet the converting of ordinary commercial current into high frequencies, applying them as localized, controlled heat for surface hardening, brazing, melting, annealing, forging and other heat treating intrigues the aircraft industry because of possibilities of increased output, simplification and strengthening of product.

A certain heat induction system (Thermonic) has borrowed from radio broadcasting, converting electrical energy into fully controlled heat energy. Rigid control prevents alteration of metallurgical properties of adjacent sections. By the use of power tubes frequencies of 500,000 cycles or more can be created, applied and controlled.

Commercial frequencies are usually 25, 50 or 60 per sec., these supplying light and power. For induction heating good results are secured at around 400,000 cycles. This electrical action forces changes in the molecular structure of the metal being heated at the rate of 400,000 "twists and turns" a sec., thus generating friction, causing heat.

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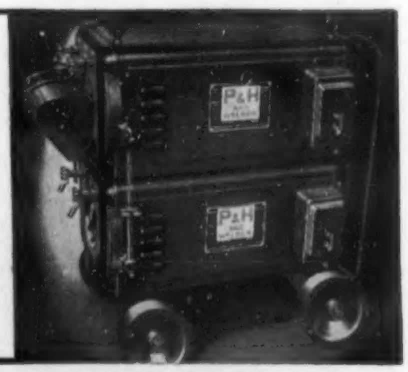

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In heating and causing internal hardening of aircraft engine cylinders distortion has been prevented. Fin brazing has been done with speed and simplicity.

In gear-hardening the whole gear is placed inside a circular coil with controls to cause high frequency currents to flow only on outside sections. As to fabricated aircraft struts, work is still largely experimental, but progress is made with silver-brazing alloy. Where steel tubing in a cast boss will sometimes break because welding reduces its tensile strength, induction heating of the boss by an enveloping split coil will increase the whole part's strength. Nor is there need to disassemble the joint made by the tubing and boss.

Experiments indicate that induction heating of prefabricated steel propellers by passing a coil gradually down the blade to give the necessary heat pattern to braze parts together will hasten the development of such propellers by doing nothing to destroy properties of the metal.

Other jobs are: Hardening meter magnetos for aircraft instruments; hardening and expanding ball bearing races. Tests show that on a typical brazing job full cost is 2½c per unit; for induction heating, 0.1 cent.

The Thermonic generator resembles a large console radio and is sturdy and long-lived. Power tube life is over 15,000 hrs.; rectifier tubes, over 9,000 hrs.

—J. Wesley Cable, *Aviation*, Vol. 41, Aug. 1942, pp. 127-128.

Aircraft Electroplating

Condensed from "Metal Finishing"

The 3 uses of electroplating in the airframe are: to prevent corrosion; to provide a smooth hard bearing surface; and to mask steel surfaces in selective hardening operations.

Anodizing is used to a considerable extent on aluminum. Anodizing has good throwing power because the oxide film has a low conductivity and the current then goes to the recesses where the film has not yet formed. A chromic acid bath is commonly used. The sulphuric acid "alumilite" process is not allowed by Army-Navy specifications on completed assemblies, but may be used on detail parts.

Related to anodizing are the "chromadizing" and the "Alrok" process. The former process is essentially a 5 min. immersion in a chromate solution heated to 140 deg. F. It forms a good base for paint but is not as good a corrosion preventative as anodizing.

The Alrok process involves immersion in a boiling solution of sodium carbonate and potassium dichromate for 30 min. Anodizing is sometimes used to accentuate cracks in aluminum forgings, to make them more visible when being removed by grinding.

Cadmium coatings, 0.0005 in. thick, are used on steel fittings. No undercoating is permitted under the cadmium.

Hard chromium plating is used on the pistons of hydraulic parts. To prevent excessive wear of the packing the machining marks must be removed from the piston by grinding and buffing. The thickness of chromium varies from 0.0015 to 0.004 in., and a tolerance of 0.0005 in. is allowed. No undercoats are allowed.

Copper plating is used as a stop-off in selective hardening of steel parts by carburizing. Tin is used in the protection of steel rivets. Zinc plating is not used to any extent in airframe construction, but its use may increase if cadmium becomes scarcer.

—R. R. Janssen, *Metal Finishing*, Vol. 40, pp. 247-251.

Flame-Cutting Heavy Steel

Condensed from "Welding Journal"

When an operator first attempts to cut material much heavier than usual he has the tendency to use an unnecessarily high oxygen pressure. The oxyacetylene process depends simply on the chemical reaction between oxygen and red hot iron or steel. Enough oxygen must be supplied but an excess is like too much draft which blows out a fire.

In case of too much oxygen pressure on a thick piece the cut will start right on the corner but soon it will not penetrate all through—instead, a rounded cavity is being formed. Or possibly the kerf will flare out at the bottom, perhaps 1 in. in width. One must always use pressures recommended by the blowpipe manufacturer.

In cutting holes mark the outline with chalk or punch. Hold blowpipe about ½

in. inside the outlined area. Heat surface almost to melting, gradually press down cutting-oxygen lever, advancing blowpipe with nozzle perpendicular to surface, tracing a line $\frac{1}{2}$ in. in from finish line.

When the blowpipe has advanced 2 in., cut should be penetrating entire thickness, the cutting valve now open all the way. Advance blowpipe along finish line and end by cleaning off the narrow section near point of starting. To start on a round bar or shaft first make a deep nick with chisel and sledge. Usually the maximum thickness for blowpipe alone is 18 or 20 in.

An oxygen lance, used alone or with a blowpipe, can make cuts up to 8 ft. thick. The lance is steel pipe connected through an oxygen hose to a regulated supply of oxygen, usually in two or more connected cylinders, with a manifold regulator for control. A piece of 1 in. extra-heavy 3 ft. pipe should be bent 90 deg. and connected to the oxygen hose through a reducing coupling and standard oxygen hose connection, this pipe being a handle for the lance.

The lance pipe must have threads that work easily since several replacements may be used during the cutting since the pipe is consumed, the burning of the pipe furnishing the heat necessary to keep the cut going.

The simplest way of heating a starting spot is a cutting or welding blowpipe. Or, a red hot rivet or red hot coals will do. Or, heat the end of the lance pipe in a fire until red hot.

With the oxygen lance it is best to have two men, one for the lance and the other to manipulate the manifold regulator. Maximum oxygen pressure is 75 lbs. per sq. in. for medium carbon or machinery steel with up to 0.50 per cent carbon, and about 100 lbs. per sq. in. for mild steel.

Used alone, the lance is very effective in piercing holes. Only 2 min. is needed to sink a hole $2\frac{1}{2}$ in. in diam., 1 ft. long, into solid steel. Hence, it is good for tapping blast and open-hearth furnaces, etc.

For piercing small holes accurately a modified lance is useful, a shut-off valve being placed between the hose and lance. Accurate holes through metal 2 ft. thick result.

Lance and blowpipe are often used together, the blowpipe furnishing the heat for the top surface and the lance carrying the cut to the bottom. Provision must be made for the free flow of slag out of the kerf bottom.

Heavy cuts can also be made by using two lances together. The second lance carries off the slag from the bottom, with less oxygen consumption resulting.

—R. B. Aitchison, *Welding Journal*, Vol. 21, June 1942, pp. 395-398.

Electric Oven Furnaces

Condensed from "Machinery"

Eight makes of electrical heat-treating oven furnaces are described in considerable detail [though the author makes few, if any, comments on merits, or on what types are best for certain kinds of work; the article is therefore primarily descriptive detail]. Chiefly medium sizes are treated.

One series has ribbon type heating units, on all four sides of the heating chamber, supported in refractory slots. Elements have a heavy cross section at terminals to keep as cool as possible. Temperature range is up to 1850 deg. F., sometimes 2100 deg. F. They have a one-piece chromium-nickel alloy floor plate. The smallest furnace has a rating of 13 kw., taking $1\frac{1}{4}$ hrs. to reach 1500 deg. F.; the largest has an 85 kw. rating, taking 3 hrs. to reach 1500 deg. F.

Another type for production hardening, tempering, annealing and carburizing consists of a heavy steel shell on angle iron legs, with a cast front. In the two smallest, chromium rod heating elements are on the chamber's roof and sides. Perforated porcelain muffles protect the side heating elements. On the larger sizes elements are on the side walls and under the floor plate. Capacities range from 12 to 70 kw.

Another line for production is built of heavy steel plate, reinforced with structurals. The door is of heavy ribbed steel, insulated. Chromium-nickel alloy rod, as elements, surround completely. They operate up to 2000 deg. F. and rate from 4.5 to 105 kw.

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Another group uses a centrifugal fan to secure heating uniformity. These are adapted to drawing and tempering of steels, annealing of non-ferrous metals, brazing of aluminum, annealing of cast iron, hardening of steels and annealing or normalizing of either rolled or cast steel. Return-bend, round-rod heating elements in radiant plates, held by fluted T-supports are employed. They rate from 14 to 95 kw.

A 6-series extends up to 2750 deg. F., and down to 1200 deg. Heavy gray-iron castings form front and back; the dome and sides are of heavy steel plate. The door, inside the furnace shell, when closed is sealed by grooves at the top, bottom and sides. Rod-shaped heating elements are below and above the hearth. The range is 10 to 100 kw.

Designed for heat-treating high-speed steels are three furnaces. An insulated steel shell, up to 2500 deg. F. is possible. Elements are above and below a silicon-carbide muffle chamber. Terminals are air-cooled and electrical contacts are shielded. The smaller sizes will heat to 2350 deg. F. in less than an hour; the largest in 1¼ hrs. Furnaces can take holding blocks of carbonaceous material which, at 2300 deg. F., produce a neutral gaseous atmosphere for high-speed steel tools. Ratings are 10 to 26 kw.

Another type hardens long tools, vertical, to prevent warping, operating up to 2500 deg. F. It has a removable silicon-carbide muffle chamber and a vertical lift door. Carbonaceous blocks can be used. Ratings are 16 to 32 kw.

Another series heat treats up to 2300 deg. F. Alloy-wound heating elements are in the top, bottom, side walls and heating chamber rear. Refractory muffles having one end closed are provided. Heater plates can be reversed to form a muffle. Ratings are 2.5 to 24 kw.

A series of 4 furnaces is suitable for nearly all heat-treating operations needing up to 2500 deg. F. Lining is high-temperature refractory, plus two layers of insulating brick and a third of block insulation. Hearth and baffle plates are bonded silicon carbide. Elements are non-metallic pin type with air-cooled terminals, mounted horizontally above the chamber and below the hearth. Ranges are 18 to 52 kw.

—Holbrook L. Horton, *Machinery*, Vol. 48, August, 1942, pp. 133-136.

Forging Aluminum Alloys

Condensed from "American Machinist"

In a previous instalment (see METALS AND ALLOYS for July, p. 154) the differences between the forging of aluminum and steel were reviewed. Similar furnaces can be used, but the temperature is lower for aluminum and a closer temperature control is desirable. Aluminum requires about the same power as alloy steels (for example S.A.E. 4100).

Aluminum forging is usually done at 750-840 deg. F. on drop hammers, but can be somewhat higher in upsetters and in forging presses. Aluminum alloys become hot short above certain critical temperatures, so maximum furnace temperature must be carefully controlled.

Usually stock for small aluminum forgings is furnished in round rolled bars, sheared to lengths required. However, some forgings are made on ends of bars and cut off in the final stroke.

Small forgings are often made on board hammers with the rough forging made in the first cavity of the die and finished in the second cavity. Large forgings are usually made from "pancakes" which are rough forged, trimmed, reheated, and finish forged in another die.

Dies are lubricated with a mixture of oil and graphite to prevent galling of the metal. The entire die is lubricated between the making of each forging, while the upper die is lubricated after each blow.

Among the largest forgings produced are propeller blades for aircraft applications which are roughly shaped hot by passing 6 times through a pair of grooved forging rolls, then inspected. Laps and cracks are chipped out before the forging is reheated for forging in a blocking die. The forging is again reheated before the final forging in a finish forging die in the same hammer. The forging is then trimmed and heat treated.

Small parts may be forged on toggle presses. Sometimes the piece is shaped in a single stroke; other parts require dies with two cavities for roughing and finishing. Close tolerances can be held and the operation is much more rapid than hammer forging. After heat treat-

ment, which varies with the alloy, the warpage from heat treatment is corrected by hand straightening for small parts or by cold striking in a die for large parts.
—Herbert Chase *Amer. Mach.*, Vol. 86, June 25,
—Herbert Chase, *Amer. Mach.*, Vol. 86, June 25, 1942, pp. 644-647.

Joining Steel and Aluminum

Condensed from "Light Metals"

It has been learned that German engineers of the Presswerk-Derendorf have developed a method of press forging for the integral joining of steel or other heavy metals, and aluminum alloys. While complete details are not available, some photographs of typical examples are shown and some of the potentialities are brought out.

The advantages to be obtained are obvious: Ability to use inserted steel members at points of wear, stress, bearing, etc. without loss of light weight. Corrosion resistance must naturally be considered. Internal corrosion at joints between aluminum and steel should not be a problem with properly forged work, where no internal space exists at the aluminum-steel interface. As for external corrosion, this could be taken care of by painting.

Copper alloy inserts, brass for example, must be very carefully protected to prevent contact corrosion as brass forms a more damaging couple with aluminum than steel. At the other extreme is stainless steel, whose couple with aluminum is relatively weak. The steel inserts are serrated to prevent rotation, and are heated before pressing into the aluminum alloy. The latter, having a higher expansivity than steel, shrinks very tightly around the steel.

One illustrated application is a ventilator fan in aluminum with a forged-in steel hub. Levers of aluminum with forged-in bushings are cited as another example. A rather extreme case is that of a light alloy milling cutter with hub and tool holders of steel.

—*Light Metals*, Vol. 5, June 1942, pp. 230-231.

Grinding and Polishing of Welds

Condensed from "Sheet Metal Industries"

All fusion welds to be finished flush with the sheet or plate surface should stand in relief above the remaining surface so there are no small pockets which would be the loci of chemical attack. Horizontal portable grinders with straight, cone or specially shaped wheels are extensively used, although vertical grinders with flaring or straight cup wheels are preferable on flat surfaces.

Soft welds, *i.e.*, aluminum, copper, duralumin, and magnesium, present greater difficulties than harder welds because the soft metals cling to the abrasive and fill up the cavities between the grains causing loading or glazing of the wheel. This condition can be eliminated by dressing but this causes rapid wearing down of the wheel. The tendency of the wheel to load may be lessened by rubbing tallow or paraffin over the cutting surface of the wheel.

As coarse a grain wheel as possible should be used. If it is not possible to get a wheel of the correct grade, the speed

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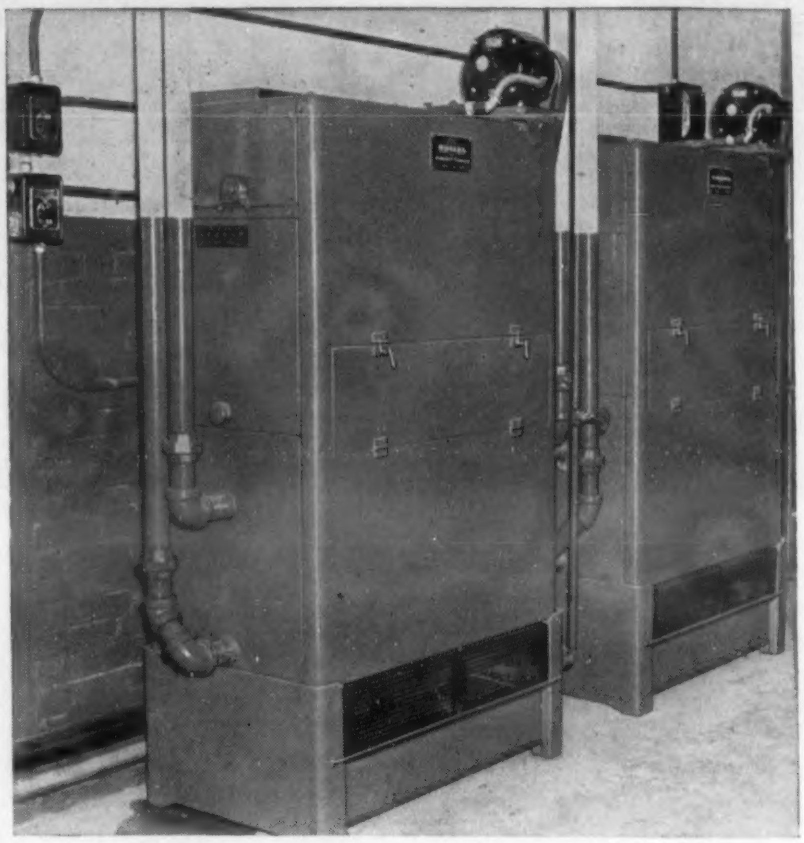

Niagara Aero Heat Exchangers in use by SKF

FASTER PRODUCTION OF HEAT-TREATED PARTS

Secured by Accurate Control of Quenching Temperature

● Proper control of temperature... both by cooling the quenching bath during use and by heating it to proper temperature when cold... prevents spoilage, produces uniform physical properties and increases production speed.

Example: One manufacturer increased production from three to five units in the same time-period by installing the Niagara Aero Heat Exchanger in connection with his heat treat quenching.

If you have a problem of temperature of an industrial liquid, as in quenching, wire-drawing, broaching, rolling, wet grinding, hydraulic machinery, water-jacketed equipment, lubricants, coolants, chemicals or intermediates, the Niagara Aero Heat Exchanger offers positive automatic temperature control at lower cost. No cooling tower is needed; 95% of cooling water is saved. Closed system prevents contamination.

Write for Bulletin 90

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INDUSTRIAL COOLING • HEATING • DRYING
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may be varied. For example, a soft wheel may be made to act more like a hard one by increasing its speed.

Stainless steel fusion welds should first be rough ground with a No. 24 or 32 grit rubber or bakelite bonded wheel with a peripheral speed of 9000 ft./min. since these wheels cut much faster than ordinary emery wheels and do not load up. The next wheel should be cotton, fairly soft, set up with glue and No. 80 abrasive, and used dry. This abrasive should be followed with No. 100 or 120, used on cotton wheels, but with the cutting surface greased to prevent scratches. Peripheral speed for all three cotton wheels should be 6000-7000 ft./min.

In polishing aluminum welds, too-coarse abrasives should not be used as it will take too long to eliminate the scratches if the weld must be polished. The direction of the strokes should be changed when changing from one size of abrasive to the next finer. A felt wheel with No. 180 abrasive gives a much better finish than a cotton buff.

The use of plenty of grease on all aluminum polishing gives a much better finish and prevents drag marks on the metal. Tripoli or dry lime or white "diamond" compound on the buffing wheel should be used for the final finish. Rouge base polishing compounds should not be used as they give the aluminum a reddish tinge.

—A. J. T. Eyles, *Sheet Metal Ind.*, Vol. 16, July 1942, pp. 1039-1040.

Flash Butt Welding of Chrome-Moly Steel

Condensed from "Sheet Metal Industries"

In flash butt welding, an arc is created between the two parts to be joined and is maintained by steadily moving the pieces together as the edges are "flashed off" until the steel immediately behind the molten surface is in a plastic condition. Then the current is cut off as an upset action suddenly butts the parts together so that the molten steel is extruded to the edges of the joint forming a ring.

This procedure has been used in the automotive industry for some time because of the low cost, high rate of production and excellent weld properties, but its use for chromium-molybdenum steel is still in the development stage. Since chrome-moly steel is air hardening, preheating may be necessary and can be done electrically or in a gas furnace. About 1200 deg. F. is required to give a nearly uniform hardness across the weld.

A somewhat higher upset pressure is required for chrome-moly than for mild steel as a result of the lower thermal conductivity, narrower plastic range, and greater hot compressive strength of the alloy steel. Chromium and molybdenum both tend to form oxide inclusions in the weld so the impact must have sufficient force to exclude all traces of oxidized molten metal; perhaps 25% greater impact is necessary than for mild steel.

In many cases, normalizing or heat treating after welding is not necessary, especially if the part has been preheated. As a result of these different properties of chrome-moly steel, welding practice for this grade must incorporate a relatively long flash burn-off period and a large upset at heavy pressure.

Destructive testing of many samples indicated that 100% of the parent metal strength can be achieved if necessary and that the joint strength is more than sufficient to take care of the maximum stress even though infrequent pin-holes may occur when a light flash procedure is used.

The secondary voltage should not be more than 8-9 volts as otherwise deep blow holes are formed which are not forged up during the upset. Full hard cold rolled copper is preferable to cast copper for the welding dies.

The flash is quite hard and shows little or no response to annealing. However, tolerances of ± 0.010 in. can be consistently produced without subsequent machining. Production speeds of 200-350 welds per hour with one operator on an automatic welder are not unusual.

No other welding method presents such low unit costs because the principal item is labor with power and maintenance expense negligible. In the aircraft industry, a flash weld is the only type which at present can be used in tension, such as on aircraft tie rods.

—W. Stuart Evans and V. V. Netchvolodoff, *Sheet Metal Ind.*, Vol. 16, July 1942, pp. 1025-1030; 1033.

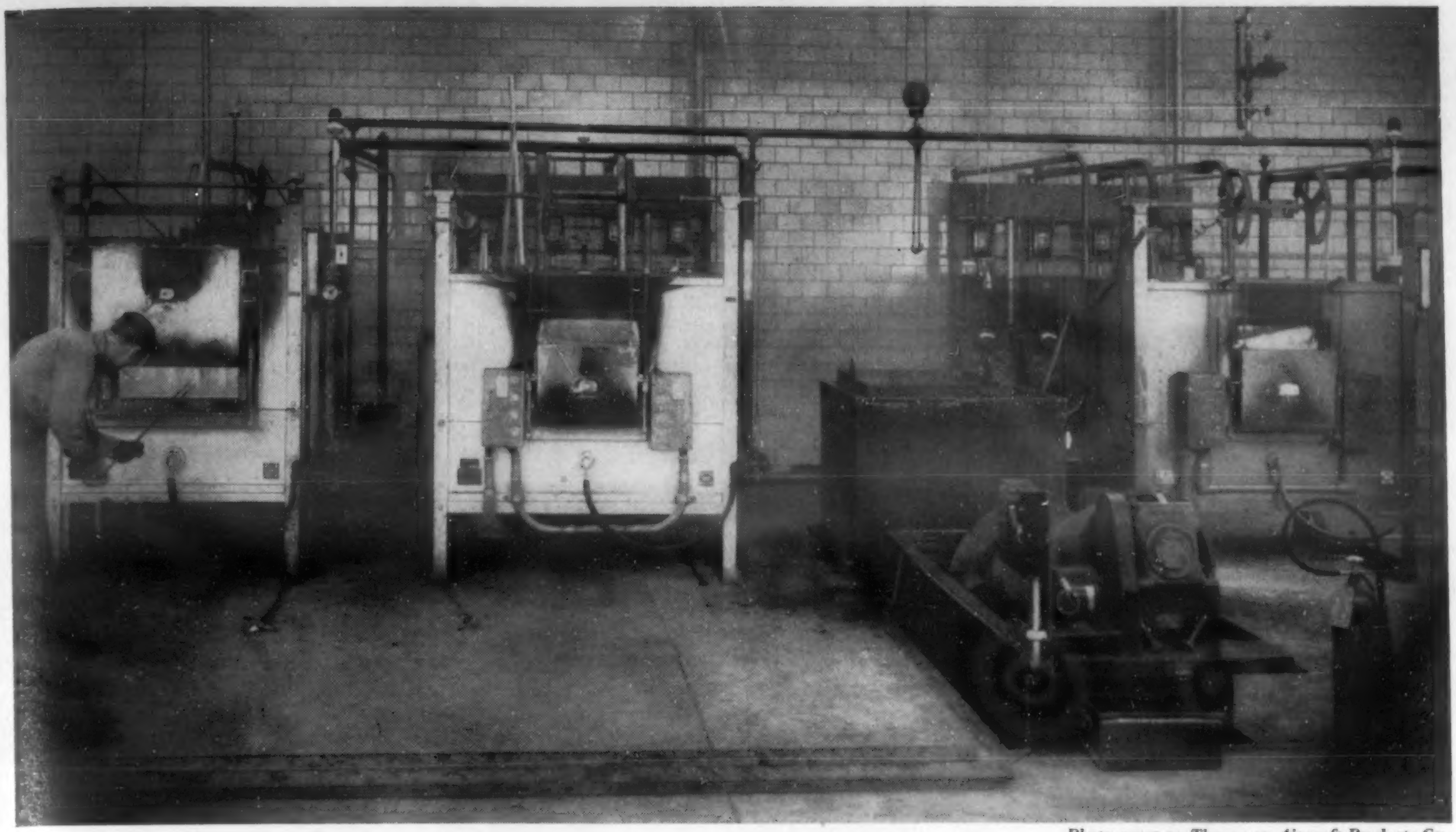


Photo courtesy Thompson Aircraft Products Co.

3 Design and Applications

METALS, ALLOYS, METAL FORMS
ENGINEERING DESIGN, METAL SELECTION

Physical and Mechanical Properties (including Fatigue and Creep) • Corrosion and Wear • Engineering Design of Metal-incorporating Products • Selection of Metals and of Metal-Forms • Competition of Metals with Non-Metals • Specific Applications of Metals and Alloys

CONTENTS

Ordnance Redesign Saves Materials

Condensed from "Product Engineering"

The greatest program of design and redesign in the history of the United States is now in full progress, chiefly of course in the production of war materials. By far the majority of redesigns results from scarcity of basic raw materials.

Army and Navy ordnance departments are sometimes criticized because of apparent ultra-conservatism in making changes in standard equipment. This is largely because it sometimes takes years to prove certain equipment, hence reluctance to try something else, since costly failures, such as gun explosions, might kill our own gunners.

However need for conversion as to raw materials and redesign of equipment was recognized by the Ordnance Department a year and a half ago. At first "strategic" materials consisted only of aluminum, magnesium, nickel and zinc. Now have been added tin, vanadium, molybdenum, copper, tungsten, chromium, high grade zinc, manganese, alloy steel, sheet and strip steel, steel plates and others.

Substitution of steel for brass in cartridge cases will have proved one of the most interesting substitutions in the history of ordnance. In 1942, 100,000,000 lbs. of critical copper will have been saved, in 1943, 591,000,000 lbs.

Elimination of rubber in tank tracks is another weighty accomplishment, more than 85 per cent of former requirements having been saved through use of combinations of castings, stampings and rolled steel special sections.

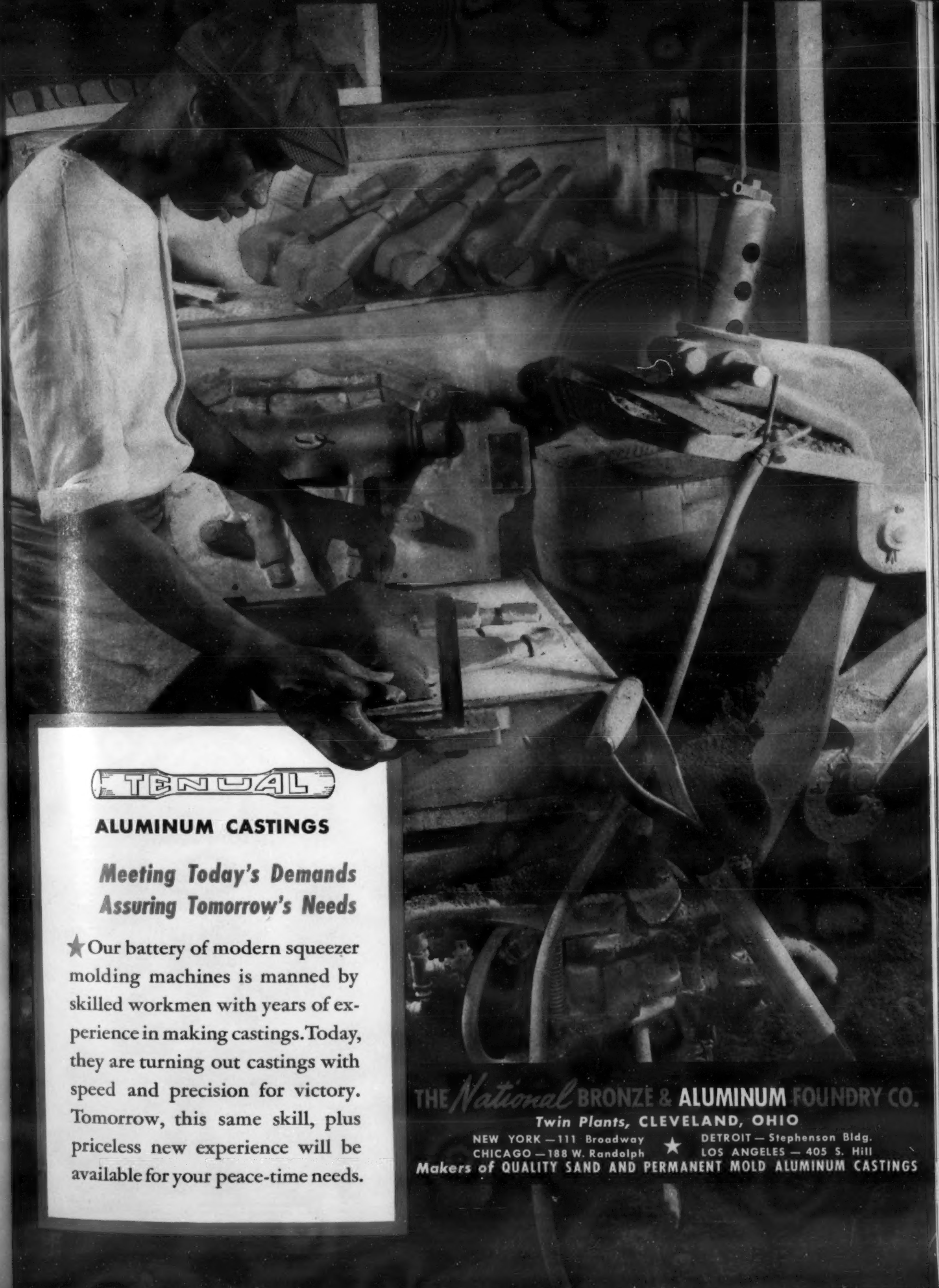
Germans used steel cartridge cases in the first World War and again in this but probably the empty cases have to be rammed out, thus being unsuitable for barrage or other rapid fire. But our new steel cases are as satisfactory as brass and orders have been placed with 45 manufacturers.

"Obturation" (that ballistic property whereby a metal cartridge case or shell expands with the initial blast and then returns to original size and form) was the hardest characteristic to develop in a steel case.

In Europe they first tried making them in two or more parts; others tried partly brass and partly steel. One idea was seamless steel tubing, to which was flash welded a stamped head. Metal in or near the weld usually failed. Another European design was partly closing one end of a steel tube, then riveting and spot welding it to a flat steel plate, allowing overlap for extraction after firing. A variation was to force the partially closed end into a brass ring. The hole left was closed with a large brass rivet which held the primer. But the case burst or failed to contract—and stuck.

Hence the one-piece steel slug finally proved successful here. The automotive industry had already done deep drawing well, such as with the one piece fender. Steel quality and heat treatments were the answer.

Yet fender making was not quite right for steel cartridge cases. The cartridge steel blanks are cupped and drawn in a succession of presses and dies with intermediate annealing. Die design was im-


TENUAL
ALUMINUM CASTINGS
Meeting Today's Demands
Assuring Tomorrow's Needs
★Our battery of modern squeezer molding machines is manned by skilled workmen with years of experience in making castings. Today, they are turning out castings with speed and precision for victory. Tomorrow, this same skill, plus priceless new experience will be available for your peace-time needs.
THE National BRONZE & ALUMINUM FOUNDRY CO.
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portant. The final result was a steel of comparatively simple analysis, cold worked with careful annealing throughout.

Practically all sizes of artillery cases are now made from steel. Against corrosion, they are given a special phenolic varnish, resistant to the chemicals of the gun powder, the use of such a case being comparatively short-lived.

Finally, a steel gun platform has been devised to supplant aluminum, for 90 mm. anti-aircraft guns. At first it appeared as though steel would delay the period between set up and firing by as much as 5 min. yet today a few seconds are being saved over the original aluminum platform standard time.

—Lt.-Col. J. H. Frye, *Product Engineering*, Vol. 13, August 1942, pp. 428-431.

Lead Solders for Copper Tubing

Condensed from a National Bureau of Standards Report

The results of a previous investigation established the fact that 50-50 tin-lead alloy and 95-5 tin-antimony alloy are satisfactory for use in soldered sleeve joints in copper tubing, provided the service temperature does not exceed 250 deg. F. The 50-50 tin-lead solder meets the needs of general domestic plumbing satisfactorily, and the 95-5 tin-antimony solder can be used in applications where higher strengths are necessary or where the presence of lead is not desired.

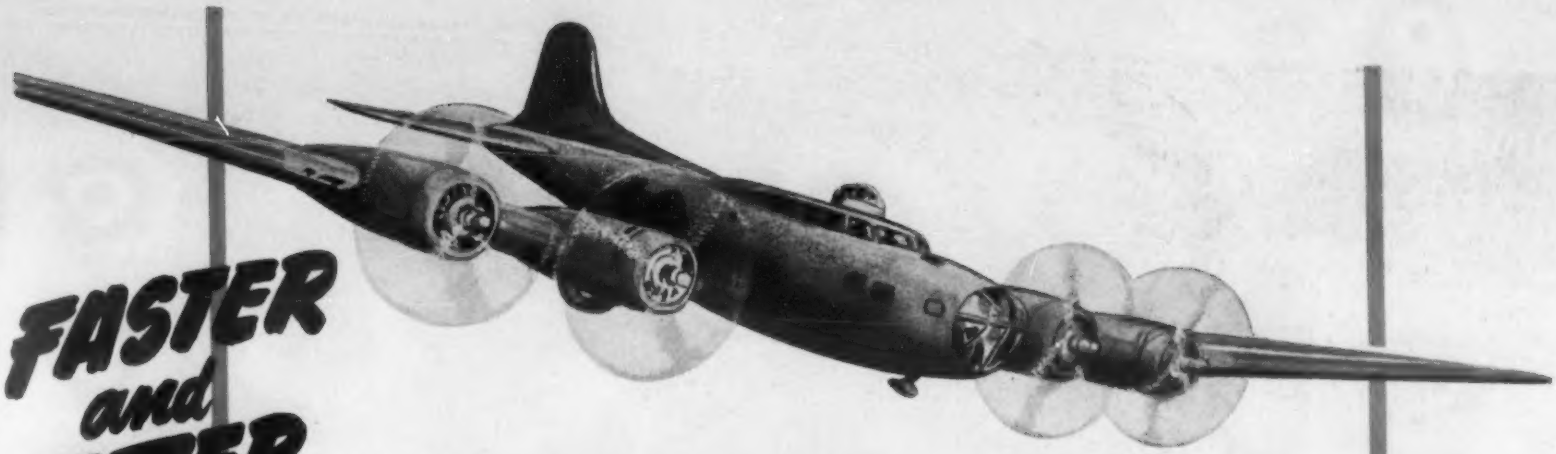
The present investigation supplemented the previous one, the principal aim being the finding of a solder satisfactory for continuous service at temperatures above 250 deg. F. Lead-base alloys of the following typical compositions were used: 95-5 lead-tin; 60-39-1 lead-tin-antimony; 95.3-4.7 lead-silver; 97.2-2.8 lead-silver; 85.4-14.3-0.3 lead-cadmium-zinc; 82-17.5-0.5 lead-cadmium-zinc; and high-purity lead.

The types of specimens and the testing procedures used were essentially identical with those of the previous investigation. Short-time tensile tests at room temperature and long-time continuous tensile-loading tests at temperatures ranging from room temperature 85 deg. F. to 325 deg. F. were carried out. Results of the latter type of test constitute a very important index of the merits of soft-soldered sleeve joints under service conditions at various temperatures.

Information concerning the tendency toward deterioration of the "bond" of a soldered joint as a result of structural changes at elevated temperatures is necessary in establishing a complete criterion for the evaluation of the permanence of soldered joints under service conditions involving elevated temperature. All of the solders that contained tin showed a tendency toward deterioration (weakening) of the bond, on long-continued exposure to temperatures above 250 deg. F.

This tendency was not observed in any of the joints made with lead-base (tin-free) solders. The maximum temperature recommended for joints made with solders containing tin, is therefore, 250 deg. F.

Within the shear-stress limitations given, lead-silver solders and lead-cadmium-zinc solders of the typical compositions tested can be used with satisfaction at temperatures up to 325 deg. F., although dif-



FASTER and BETTER

Heat Treatment of MAGNESIUM ALLOYS with DESPATCH FURNACES

Despatch Pot Type Magnesium Heat Treating Furnace. Basket 60" in diameter x 60" deep.

Despatch Batch Type Magnesium Heat Treating Furnace. One of many sizes and models to suit large scale production of castings and parts.

YOU will more than make specifications for tensile strength and elongation when the heat treating formulae can be followed with laboratory accuracy.

The fact that such close control is maintained in all Despatch forced convection furnaces, is an important reason why leading magnesium and aluminum alloy fabricators have chosen Despatch designs for their pot type, batch type and continuous conveyor type furnaces.

These furnaces speed up output considerably by faster processing and new methods for handling more material.

WIRE OR PHONE . . . A Despatch engineer will visit you promptly. He can recommend the right Despatch furnace to fit your plant.

DESPATCH OVEN COMPANY MINNEAPOLIS, MINNESOTA

ficulty may be experienced in "sweat" soldering, as in making sleeve joints, with the alloys 97.5-2.5 lead-silver and 82-17.5-0.5 lead-cadmium-zinc, which are close to the eutectic in their composition and therefore remain molten over a relatively very short temperature interval. From the standpoint of ease of application, the lead-cadmium-zinc solders are somewhat superior to the lead-silver solders.

The use of lead as a commercial solder is limited by the difficult technique required in its application.

—A. R. Maupin & W. H. Swanger, Report No. BMS83, *Nat'l. Bur. Standards*, May 5, 1942.

Plywood Planes à la Vidal

Condensed from "Automotive and Aviation Industries"

A new process for the manufacture of aircraft and other parts from plastic-bonded plywood has been developed by the Vidal Research Corp., Camden, N. J. The inventor is Eugene Vidal, formerly director of aeronautics, Department of Commerce.

A shell of plywood veneer, in three successive layers, with the grain running in different directions, is built upon wooden forms. Each strip of plywood is secured by staples. The built up article is enclosed in an airtight bag and the air is exhausted so that the treated fabric of the bag is applied to the structure with uniform pressure. Subjection to heat and pressure in an autoclave softens the plastic and welds all parts into a single mass.

The molds are made of soft wood, to prevent swelling and distortion and the bags of rubberized fabrics to avoid cracking and tearing.

The temperature in the autoclave is about 240 deg. F. and the pressure ranges from 20 lbs. per sq. in. upward. The pressure is uniformly distributed over the entire surface. This is necessary as plywood does not possess the same flow characteristics as soft metal sheets, which can be molded with uneven pressure by rigid dies.

Fuselage and wings are made in two parts and "welded" together, by means of low temperature plastics. Wings are secured to the fuselage by mechanical means. Complete planes of the smaller type including a Summit of 75 hp. and a Langley have been built. The former is said to have shown greater maximum speed than that of conventional construction.

The Vidal Research Corp. will not manufacture, but will license manufacturers to use the process. It is said that the Universal Molded Products Corp. has already shipped thousands of bomber parts made by this process. The Allied Aircraft Corp. is working on a large transport glider.

The Vidal process can be used for fabrication of many other articles. Station wagon bodies, pleasure boats, special boats for the government, and a detachable fuel tank for airplanes, have been made.

The equipment needed is very simple. Allied Aviation Corp. is curing a new type of ski and small sleds made of the material in pressure tanks formerly used in a tire factory.

—P. M. Heldt, *Automotive & Aviation Industries*, Vol. 87, July 15, 1942, pp. 28, 29, 68.

Platinum Metals in Wartime

Condensed from "Mining and Metallurgy"

Of 14 outstanding properties of platinum and its associates, palladium, iridium, rhodium, osmium and ruthenium, three deal with chemical applications—catalytic activity, resistance to corrosion and resistance to oxidation at elevated temperatures, coupled with resistance to molten oxides and silicates.

Ranking first in wartime importance is production of nitric acid by oxidation of a mixture of synthetic ammonia and air by passing it through red-hot rhodium-platinum alloy gauze. Ammonia is easily burned, yielding nitrogen in the form of nitrous oxide through platinum as a catalyst, 99 per cent efficient. With one troy ounce of the alloy 1,000,000 lbs. of nitric acid is produced.

Finely divided platinum supported by asbestos, magnesium sulphate or silica gel is a catalyst used in manufacture of sulphuric acid by oxidation of sulphuric dioxide to sulphur tri-oxide. Platinum is preferred because of its activity over a wide temperature range, high overload capacity and behavior with gases of high sulphur dioxide content.

Palladium and platinum are excellent for hydrogenation and dehydrogenation, used for making organic products, including vitamin adjuncts. Ruthenium has been used in synthesis of long-chain hydrocarbons and osmium tetroxide is an effective hydroxylation catalyst. Palladium permits rapid and selective diffusion of hydrogen, useful for furnace atmospheres.

Pure platinum is used as the anode in making many "per" salts. Platinum and iridium-platinum are suitable for insoluble anodes in electroplating and recovery of metals from waste solutions.

Availability of these metals in clad form permits economical constructions. Another use of platinum is as frangible or bursting disks for pressure vessels apt to explode. Platinum clad sheets, pipe, rod and lined reaction vessels are available in many sizes with the working surface covered with a platinum layer from 0.002 to 0.005 in. thick.

A spectacular recent achievement has been the production of fiber glass as insulation for copper wire. The molten glass passes through platinum nozzles. Other metals would melt in the glass. The rayon industry uses platinum-gold and rhodium-platinum alloys similarly, the viscose being forced through spinnerets, each having a face ½ in. diam., with 40 to 60 holes, 0.003 in. in diam. (size of human hair).

Electrical applications of the platinum group are based on resistance to tarnishing by oxidation or sulphidation, resistance to spark erosion, their high melting temperatures and good mechanical properties. Palladium is good for contacts of telephone relays. Platinum pure or combined with ruthenium or iridium, are used for contacts in voltage regulators, thermostats and relays and for high tension magnetos in aircraft. Spark plugs with platinum-alloy electrodes are used extensively in this war.

Platinum electrical fuses will glow at a few thousandths of an ampere. They are used for detonating explosives.

The platinum group is versatile and can shine as jewelry or can put its shoulder to the wheel and perform a whole gamut of useful chores beyond the ability of lesser metals.

—E. M. Wise, *Mining and Metallurgy*, Vol. 23, August 1942, pp. 421-425.

Substitutes for Tin Plate

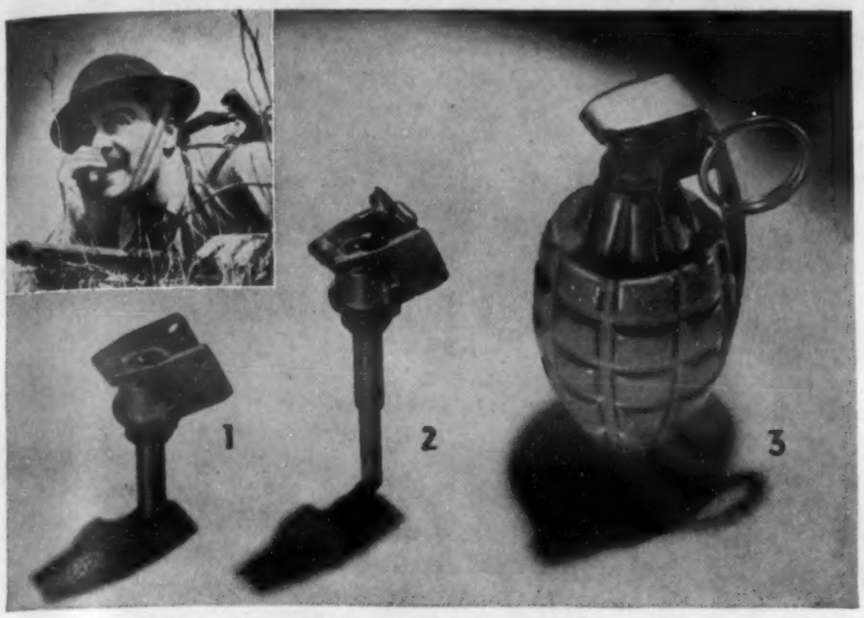
Condensed from "Iron and Steel Engineer"

Tin coating on plates, and fabricated into cans, generally serves four main purposes: Provides protection on the outside against rusting in storage, gives protection on the inside against corrosion by contents, maintains the original clarity and flavor of the contents, and permits soldering at mass production rates.

Most tin plate is made by hot-dipping. Electrodeposition of tin has been experimented with but data are limited and anyway, scarce tin must still be used. An electrogalvanized product might do for nonfood containers but zinc is scarce and has poor soldering properties. Silver would cost 28 cents per square ft., based on usual tin thickness.

Coronizing (a composite coating of nickel and zinc or nickel and tin) or other combinations might do, but these are usually critical metals. When using black

DIE CAST BOUCHONS FOR HAND GRENADES



The bouchon is "the business end" of a grenade.

The well-known fragmentation "pineapples" which served our fighting men so well in World War I are equipped, in this war, with ZINC Alloy Die Cast bouchons. This part is particularly well adapted to die casting production because in its detail it constitutes a rather tricky design and, as a die casting, it can be turned out at high speed with practically no machining.

The three steps in the above illustration show (1) the die cast bouchon (2) the bouchon with the booster assembled at the bottom and with the spring firing cap at the top (3) a complete grenade with the release handle and the release ring-pin assembled to the bouchon.

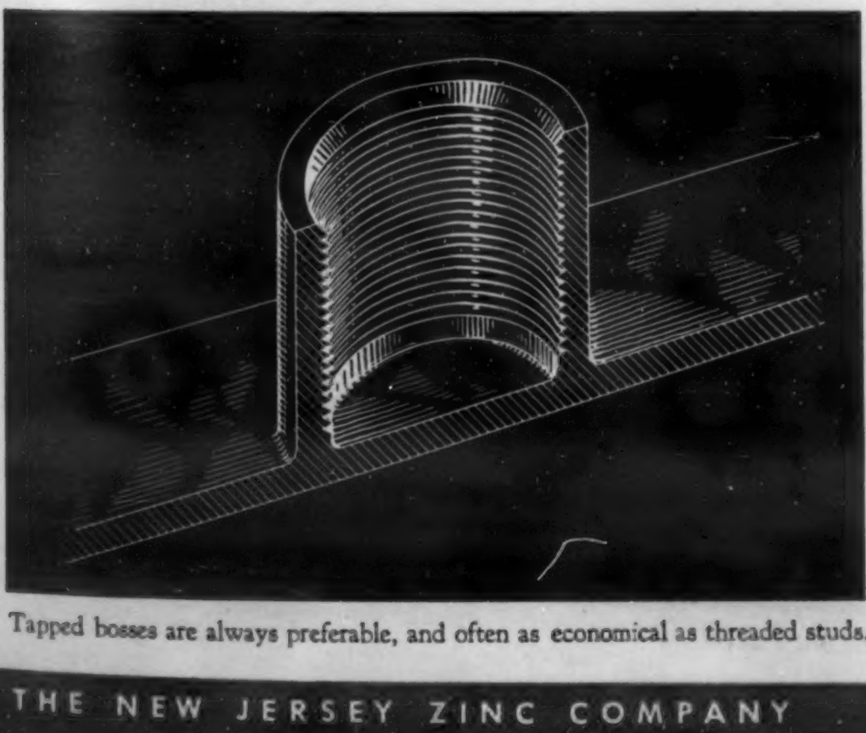
As shown in the inset, the soldier first removes the pin by pulling the ring (in this case with his teeth). This permits the release handle to fly off when the grenade is thrown, springing the firing cap to its charge in the bouchon and thence through the booster to the deadly T.N.T.

TAPPED BOSSES PROVIDE STRENGTH

In designing a part for production by die casting it should be remembered that tapped bosses are stronger than threaded studs (because external threads cause a notch effect in case of shock loads).

With tapped bosses, however, the precaution must be taken to allow 1/8″ at the bottom for chip clearance (see drawing). Failure to provide this clearance in any one boss may add as much as 5% to the cost of the casting, through frequent tap breakage. In addition, a tapped hole should be counter sunk 1/32″ larger than the thread for ease of tapping an assembly.

For other hints on good die casting design practice, write to us—on your company letterhead—for a copy of the booklet "Designing for Die Casting."



Tapped bosses are always preferable, and often as economical as threaded studs.

THE

New Jersey zinc

ALLOY POT

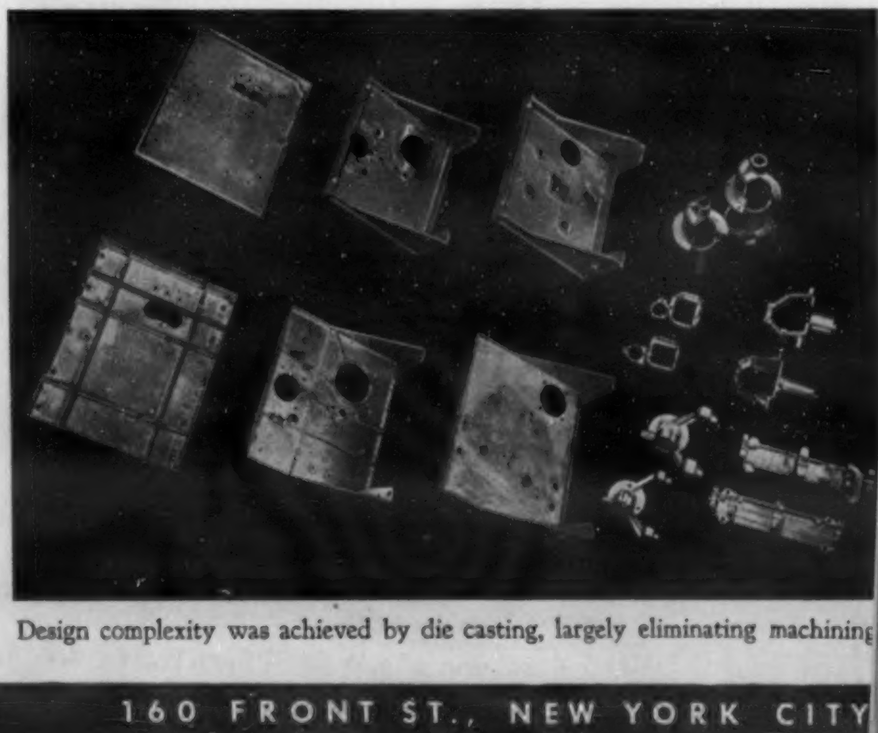
A publication issued for many years by THE NEW JERSEY ZINC COMPANY to report on trends and accomplishments in the field of die castings. Title Reg. U. S. Pat. Off.

METALS AND ALLOYS EDITION

ZINC ALLOY DIE CASTINGS VS. SAND CASTINGS

In the redesigning of many products, die castings have been adopted to serve where sand castings were previously employed. The reason for this conversion is usually one of simple arithmetic.

Shown below are eight sand-casting-to-die-casting conversions of parts for a navigation training device used in the aviation field. The sand castings, at the background in each case, cost $8.44 for a set of eight. The ZINC Alloy Die Castings, foreground, cost $3.43 a set. In addition, it cost $33.64 to machine the sand castings and only $14.15 to machine the die castings. Thus the total saving on the redesign of the eight castings effected a total saving of $24.50 a set.



Design complexity was achieved by die casting, largely eliminating machining

plate with lacquer or enamel coating, sizing or lacquering must be done immediately as any incipient rust will grow under the subsequent enameling.

Oiling of plate provides only a nominal protection until decorated. Wool oil affords only limited protection. Certain other oils give a fair measure of protection. Lithographing or lacquering supplies only a nominal amount of surface protection, though incipient rust pitting is a threat.

Enameling of black plate has shown some promise but is not the final answer. There are three main problems: Rust protection before coating must be provided, underfilm corrosion must be eliminated and enamel adhesion must be good.

Bonderizing and phosphoric acid treatment have given best results, with the former better for sanitary cans. Bonderizing must be followed by lacquering. This combination meets fairly well requirements outlined in the previous paragraph. However elaborate equipment is needed for bonderizing and it must be lacquered on both sides. Moreover it can't be soldered and may be limited to end stock.

Phosphoric acid is less satisfactory than bonderizing. Phosphates, chromates and borates, and combinations, either lack rust prevention or lacquer adhesion properties.

Oxide films must be oiled and are doubtful. Stainless or clad steel are impractical because of critical metals involved. Enameled sheet of the vitreous type involves high temperature and involved handling. Glass containers are heavy and expose the product to light.

In conclusion, no "perfect" substitute for tin has yet been devised and the public must knuckle down to lower standards, for the time being, at least.

—C. E. Brown, *Iron and Steel Engineer*, Vol. 19, July 1942, pp. 30-37, 74.

Replacing Steel with Cast Iron

Condensed from a paper for the Institute of British Foundrymen

Stress is laid on what advantage engineers have so far taken of revolutionary developments in the manufacture and engineering properties of cast iron. The first part of the paper features instances of replacement of steel castings by high-test iron.

The second portion of the paper describes how the small iron-founder, in many cases still untouched by these developments, can proceed to make high-test iron. The third section discusses the latest trends and probable future developments in the high-test iron field.

High speed Diesel and gasoline engines are now fitted with cast iron crankshafts as a matter of course. Before Ford fitted his mis-named cast iron (actually hyper-eutectoid cast steel) crankshafts to his standard car models, many American manufacturers had been using high strength gray iron crankshafts for refrigerators and similar machinery, but kept the matter secret because of public prejudice against cast iron.

High test iron is being extensively used for spindles; a 45-ft. by 15-ft. solid boring bar made of cast iron, which replaced a costly steel forging is illustrated. It has been found possible with spindles of Meehanite, for example, to operate lathes, milling machines, etc., at a much higher speed, utilizing the remarkable properties of carbide cutting tools to their fullest advantage on account of the vibration-absorption properties of cast iron.

A horizontal boring machine main spindle neck bearing made from a typical good grade of gray iron is also shown. This revolves in a bronze bushing, and the bearing qualities of the combination are excellent. Apart from its tensile properties, this iron has excellent machinability, taking a fine finish even when extended to fine screw cutting on heavy sections.

In one type of horizontal boring machine, the main traverse rack and column-rotating rack of which, formerly made in 0.4 per cent carbon steel, were replaced by high-tensile gray iron having a tensile strength of 55,000 lbs. per sq. in. In another case—a heavy high-speed planing machine—the main table rack and tool clapper boxes, formerly of steel, are now made of gray iron.

In the case of the replacement of steel gearing the improvements in gear-cutting methods have greatly helped, and the "quietness" in operation of high test cast iron gears is now an accepted fact. Among the other substitutions mentioned are hydraulic pump bodies, connecting rods and

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by the Bridgeport Brass Co. "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Laboratory Vital to Production of High Quality Copper Alloys

Research and Development Have Assumed Utmost Importance In Meeting Customers' Needs, Producing Better Alloys

The words "laboratory control" are quite familiar to customers of the Bridgeport Brass Company today, yet only fifty years ago there was no such thing as laboratory control of metallurgical production.

When a customer used to send in a sample for duplication, the Mill Superintendent inquired what the material was to be used for. He guessed at its composition by scratching the surface and studying its color and tried to judge its degree of softness or hardness, as the case may have been, by flexing the sample between his fingers. He then took it over to the casting shop and instructed the caster to make up the material, in accordance with the caster's best judgment.

"Hit or Miss" Method

After a sample lot was processed and sent to the customer, the salesman inquired whether or not the material was entirely satisfactory. If it was necessary to change the alloy or temper, this was done until word was received from the customer that the correct material had been evolved. The caster then secretly recorded the satisfactory mixture and from that time on changes would not be permitted under any circumstances. In this way, every customer received special material which meant that there were a large number of individual alloys, each named according to its applications. Such mixtures as clock brass, button brass, eyelet brass, shoe hook brass and hinge brass were developed.

The chemist entered the brass business about 1890. His duties began with analyzing the customers' samples and instructing the caster as to the mixture. He was able eventually to classify the various mixtures and thus standard alloys were gradually established. The chemist also analyzed the scrap which went into the melt and thereby put himself in a better position to keep the alloys under control.

Gradually testing instruments such as the tensile machine, scleroscope and Brinnel were adopted to help determine the physical properties and related tempers of incoming samples. With the establishment of definite customer specifications, it also became necessary to test the finished product. In this way the chemist, now developed into a metallurgist, took over the scientific end of the brass business. Pyrometers for measuring the temperatures of furnaces for annealing and melting metals and the metallurgical microscope for studying metal structures were added to his instruments, thus enabling him to supervise the technical side of processing brass mill products.

Bridgeport's Laboratory

The brass industry owes much to the metallurgist because it was he who put it on a scientific basis. In Bridgeport, the Metallurgical Department is considered just as essential as the most important operating departments in the company. Chemical analyses of all incoming raw materials which are used in making brass—such as copper, zinc, scrap and fluxes—are made by a completely equipped and organized department. Spectrographic analyses are made to detect the small amounts of elements detrimental to processing and to ascertain the presence of those minute quantities of elements which serve to improve the alloys. Cast samples are analyzed to make sure that castings are "on mixture." After castings have been processed in the mill, further checks are made on the finished products to make certain that they meet customers' specifications. All of this work is part of the constant effort exerted by Bridgeport to maintain the

The Rockwell hardness testing of finished materials is part of Bridgeport's careful check-up on production to meet customers' specifications.

uniformity and high quality of its products.

The physical testing laboratory performs a wide variety of tests for grain size, hardness, tensile strength or electrical conductivity, depending upon what properties are required to meet the customers' needs.

The laboratory also acts in a maintenance capacity by regularly checking the analysis of various pickling and plating solutions to see that they are maintained to standard strengths for satisfactory operation.

Research and Development

Probably the most important and valuable activities of the laboratory are the research and development departments. Here new alloys and products are brought out and the properties of standard alloys and the methods of processing improved. Countless tests are also carried out to accurately determine such factors as corrosion resistance, season and corrosion cracking, fire cracking, creep under stress, fatigue stress, gas content, cold and hot forgeability, machineability, etc.

A group of men especially trained in tracing down the causes of troubles encountered in processing and fabricating materials consult with the production people

(Continued on page 2, column 2)

New alloys have their beginnings in the laboratory where they are cast, processed and tested to learn their properties before they are accepted for regular production. Above are shown a miniature electric casting furnace and rolling mill in Bridgeport's laboratory.

COPPER ALLOY BULLETIN

ALLOYS OF COPPER

This is the thirty-seventh of a series of articles on the properties and uses of the copper alloys.

COPPER ALLOYS FOR CATENARY CONSTRUCTION

Practically all systems of electric transportation, as constructed at present, require a combination of contact wires and supporting structures to quickly and efficiently feed current to the operating motors without interfering with the fast moving equipment.

The overhead contact system has proven safer and more dependable, especially where the right of way cannot be completely protected. In the case of electrified street railways, the trolley or contact wire is supported from cross-span wires strung from poles along one or both sides of the street about one hundred to one hundred and ten feet apart. Between supports, the wire necessarily sags, depending upon the length of span, temperature and tension. Trolley coach overhead consists of a positive and negative wire suspended about twenty-four inches apart but carefully insulated from each other. The direct suspension systems described above are satisfactory for low or moderate speeds. Some of the difficulties brought about by excessive sag, however, can be alleviated by maintaining high tensions, such as are possible with high conductivity bronze wire.

For high speed operation such as is required by electrified railroads or interurban lines, the catenary system generally consists of a contact wire (trolley wire) suspended by means of clips and hanger rods from a messenger wire which in turn is supported from cross-span structures. By making the hanger rods of variable lengths, the contact wire lies in a plane parallel to the track. Grooved contact wire is used because it can be gripped from above so the clips and ears will not interfere with the current collector. Here we virtually have a suspended overhead track.

Materials suitable for catenary construction must possess the following properties: high electrical conductivity, great strength, toughness, and resistance to corrosion from the elements.

Bridgeport's Phono-Electric alloys—pure copper alloyed with small amounts of tin, cadmium, aluminum, etc., have been developed for electric transportation during the past fifty years. Despite the fact that they were primarily developed for this purpose, it was found that their properties are suitable for other engineering and fabricating applications. These alloys will be described in this column in subsequent issues of the COPPER ALLOY BULLETIN.

Laboratory Control

(Continued from page 1, column 3)

to help solve their difficulties. This generally results in the development of better and more economical ways of doing things, in the reduction of waste, and in the improvement of quality.

Another group of laboratory people devote their entire time to the Sales Department and customer service. They see all orders and enter instructions to insure material which will give the best results in service. They also supply the customer with technical advice when requested, and help him to select the alloy and temper for greatest economy and efficiency.

The success of Bridgeport's laboratory control is based upon the fullest cooperation with every member of the company's organization. They recognize the advantage and benefits of technical knowledge and control so necessary for maintaining the highest quality standards in the industry.

Memos on Brass—No. 32

Progressive machine operations offer both speed and economy to the fabricator of small brass parts. Not only do rapid sequence of steps on the machine cut down the time factor, but this type of operation may eliminate the need of an intermediate anneal, as the metal is formed by more gradual stages than when single operations are employed. However, satisfactory results from progressive operations depend upon correct selection and careful control of the properties of the original brass strip. Care must be taken to see that the metal is correctly annealed to withstand the forming operations or it will tend to crack during fabrication. Bridgeport is exceptionally well equipped to study the requirements of specific forming jobs and to supply brass of the necessary characteristics.

New Marking Machine

A new hand-operated marking machine that is said to do 650 or more shell noses per hour has been developed for fabricators of war materials. The maker claims it has been used successfully for marking brass parts as well as steel, aluminum and zinc.

NEW DEVELOPMENTS

An all-steel drill press vise is announced which is provided with a screw having square threads which operate against a bronze thrust bushing. It is designed so that work can be drilled completely through without injury to the vise. The vise is made in two sizes—one with a 5½-inch opening and ears for fastening to the faceplate and another with a 3-inch opening without ears. **(No. 360)**

A temporary coating is offered to reduce rejects due to rust, scratches and fingermarks on metal, ceramic and other highly polished surfaces. This liquid has a plastic base and is sprayed, brushed, dipped or roller coated. It is said to leave a flexible, transparent coating which can be removed by lifting one edge and peeling, then returned and reduced to liquid to be used again. **(No. 361)**

A precision level has been developed which will detect a variation of as little as .0025″ per foot. Graduation ines, each representing .0005″ per foot form squares about a circular bubble, thus allowing the operator to detect amount of variation from level in any direction. Four screws in the base provide adjustment for the glass assembly and the bearing surfaces are lapped by optical methods. **(No. 362)**

Plastic spacing collars are offered for milling machine arbors in ten thicknesses from 0.001 to 0.020 inches with hole diameters up to two inches. They are each made in different colors to speed up identification and eliminate time lost in micrometer calipering. **(No. 363)**

A multiple-angle drill has been developed which features a drilling head which can be set at any angle through 360 degrees and can be swiveled in two planes. The design is said to aid the fingers of the operator's hand to be close to the point of application. The drill weighs 2½ pounds and is about 8 inches long when set for drilling in a direction parallel to the center line. The chuck accommodates a ¼-inch drill. **(No. 364)**

A radius dresser for surface grinders is offered which is said to provide for dressing the grinding wheel for different radii and also for radii where a clearance angle on the radius is involved. The wheel guard does not have to be removed when dresser is used. The diamond is set by simply measuring with the micrometer from top of hood to bottom of arm. **(No. 365)**

A stop countersink with ball thrust bearing to take up shocks has been introduced. The drive shaft runs in a bronze sleeve which with the thrust bearing is said to insure accuracy and long tool life. It is hand adjusted for fast and easy cutting with the desired adjustment securely locked. This countersink is available in 7/16″ and ⅞″ cutter sizes, from 78° to 110°. **(No. 366)**

This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company, which will gladly refer readers to the manufacturer or other source.

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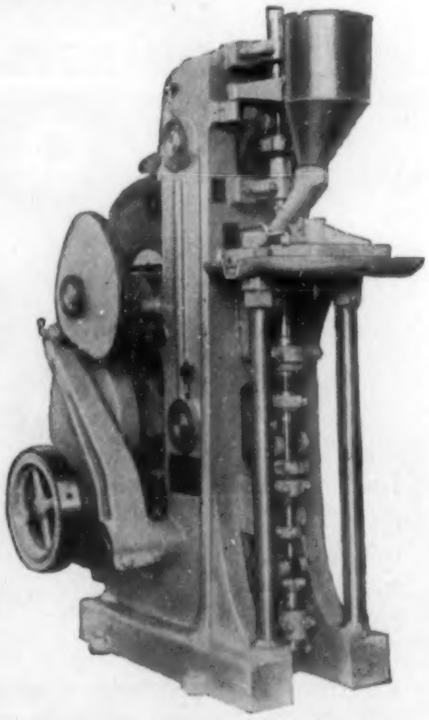
For many years we have worked closely with engineers on research and development work in powder metallurgy . . . have developed automatic presses, standard and "special" models, with up to 8" die fill, to compress powdered metals into parts up to 4" dia., to form tablets or "cakes" up to 10" dia., to produce chemical catalysts at rates of thousands per minute.



Model "S" Press, a general purpose machine, applies 30 tons pressure. Output up to 35 pieces per minute.

We recently published a new 48-page illustrated catalog which shows hundreds of parts made by tabletting, more than 24 standard and "special" presses for powder metallurgy and other tabletting operations, contains specifications, information on selection and use of equipment and other engineering data.

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cross heads; and a 250-ton extrusion press body.

It is imperative that the general metal thickness of the castings be constant, and only one casting section can be run in a foundry without changing the metal analysis. Cooperation with the designer will overcome the first drawback.

Also castings should not be specified in a higher-than-necessary grade. It is not economical to specify a 65,000 lb. iron with expensive or critical alloys when a sound 45,000-lb. iron will do the job adequately.

—J. Blakiston, *Inst. British Foundrymen*, Adv. Copy No. 752, June 20, 1942, 14 pp.

Columbium or Titanium in Chromium-Molybdenum Steel

Condensed from "Oil & Gas Journal"

Either columbium or titanium added to a steel of 5 Cr, Mo type reduces hardening after both air-cooling and welding. Both form carbides and the solubility of the carbides is low at heat-treating temperatures. The carbon is thus rendered inactive and for temperatures up to 1800 deg. F. the effect is to decrease the carbon content to less than 0.05 per cent.

The ASTM specification for chrome-moly+titanium, now being revised, will require a minimum content of titanium of four times the carbon and a maximum of 0.70 per cent. Maximum carbon is to be 0.12 per cent. The present specification for 5 Cr, Mo+Cb requires a columbium content of 8-10 times the carbon.

To reduce the hardness of pressure resistance welds and spot welds with 25 Cr-12 Ni below 200 Brinell, heat treatment is necessary but if the proper amount of columbium or titanium is present, the stabilized steel can be air-cooled from 1500 to 1750 deg. F. instead of the slow controlled cooling at a rate not faster than 50 deg. F. per hr.

In the evaluation of the influence of these two alloying elements on high-temperature strength 2 different heat treatments were considered—annealing and tempering. In the annealed conditions the steels possess a Brinell hardness below 150, while after the normalizing and tempering treatment the hardness of 5 Cr, Mo+Ti is 143 and that of 5 Cr, Mo+Cb is 170.

Regardless of the heat treatment the values for the rupture strength of 5 Cr, Mo+Ti are inferior to 5 Cr, Mo at temperatures ranging from 900 to 1500 deg. F. After both heat treatments the columbium type is superior to 5 Cr, Mo at 1,200 deg. F. while the same is true at 1,000 deg. F. only after the normalizing and tempering treatment.

Heat treatment does, therefore, have an influence on the rupture strength of the columbium modification but does not on the titanium type. Neither heat treatment has any influence on the creep strength of 5 Cr, Mo+Ti steel.

The addition of titanium reduces the strength at 1,200 deg. F. but is without influence at 1,000 deg. Columbium additions improve the creep strength with the degree of improvement being more pronounced after the tempering treatment than after annealing.

—C. L. Clark, *Oil & Gas J.*, Vol. 40, Apr. 2, 1942, p. 39; Apr. 23, 1942, p. 72.

Permopivots for precision instruments in airplanes have already been tested and proved superior. They are tipped with Permometal—a non-corrosive, smooth wear-resisting, non-magnetic precious metals alloy with a low coefficient of friction.

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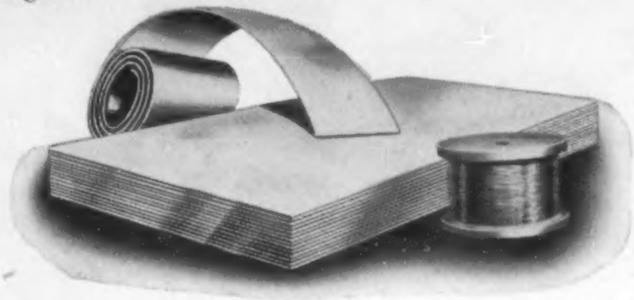

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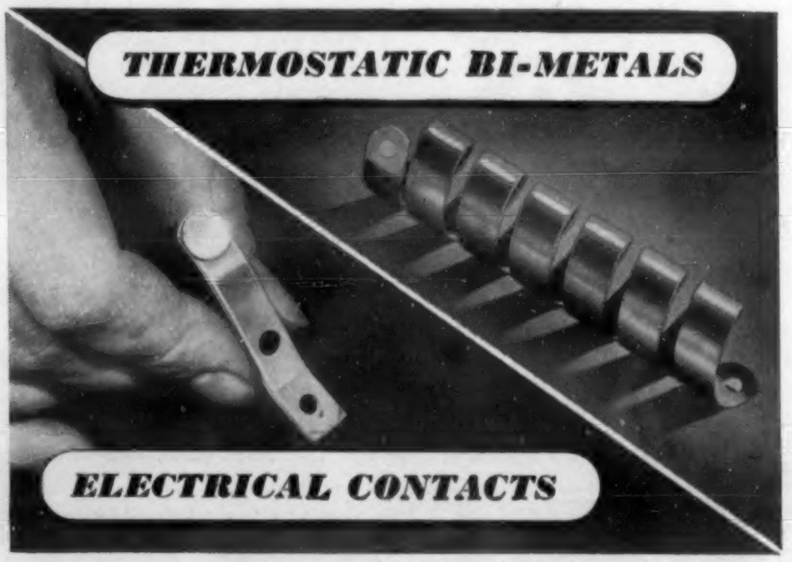

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Testing and Control

4

METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection • Routine Control and Instrumentation • X-ray and Magnetic Inspection • Spectrographic and Photoelastic Analysis • Corrosion- and Wear-Testing • Examination of Coatings, Surface Measurements • Metallographic Structure and Constitution

CONTENTS

Aircraft Strain-Gage Technique

Condensed from "S.A.E. Journal"

Strain-gage technique is of interest because the greatest aid to increased production is to simplify the original design. Accelerated progress in the solution of structural design problems has been made possible by the use of electrical resistance strain-gage apparatus.

The equipment consists of resistance units of fine wire cemented to the stressed surface under investigation and connected in a suitable bridge circuit. The cross-section, hence the resistance of the gage unit, is varied by the elongations or contractions to which it is subjected. The resulting unbalance of the bridge circuit is simplified by electronic means and recorded by suitable equipment: a recording oscillograph, if the tests are dynamic, and stylus recorders or simple visual meter readings if static.

Mechanical strain gages produce good results, usually only under laboratory conditions. In actual aircraft work, their use is limited because of difficulties of installation and of recording rapid variation of stresses.

Electrical gage units are small and, with suitable associated apparatus, are remote reading and self-recording. For each type of stress, there is a special most-suitable use of the gage units.

Types of Stress

In all work a strain and not a stress is being measured and Poisson's ratio corrections must be made wherever stresses not parallel to the axis of the gage exist. A true indication of the average axial stress and of the true axial load in the member is best obtained by the use of a number of gages so interconnected that an average of the stresses imposed on all the gages is read.

A comparison of a stress-strain curve indicated by electrical gage equipment, with curves determined by more customary means, shows that the gages are suitable for proof tests and flight-test work in which yield stresses are not exceeded for 24ST dural or equivalent, and for steel up to ultimate tensile strengths of the order of 125,000 lbs. per sq. in. For flight-test work or static proof tests on aluminum alloys, the range is satisfactory.

The permissible upper limit is not high enough to permit direct simple use beyond the yield stresses in destruction-test work. For investigations on the more highly heat-treated steels, it is sometimes possible to widen the apparent useful range by taking advantage of preload stresses that may exist.

Where a varying stress distribution is known to exist, it may be determined by a number of individual gages located at critical points. From these data, a plot of the stress distribution across the section may be made, and bending and direct stresses isolated subsequently.

If bending stresses are the sole concern, two gages are used on opposite sides of a bending member, interconnected in a single circuit so that the total stress differential is indicated. This is ideal when the problem is such that the determination of a total bending differenital stress is satisfactory.

With the direction and magnitude of the principal stresses unknown, it is possible to determine the complete state of stress on a surface if a sufficient number of strains directionally disposed at sufficiently large angles to each other are known. The use of three gages, each forming an angle of 60 deg. with the other, in the shape of a delta, is best.

The result sought is the determination of the direction and magnitude of the principal stresses. From this any components, such as the shearing stresses, may be established.

Technique

Unless it is known that buckling will not occur, deltas are installed back to back. When that is not feasible, it is possible to install two deltas on the same side of the sheet. Accuracy is gained by installing the three gages in as small a pattern as possible.

Except in total bending differential applications, dummy gages are used to balance the resistance of the gage unit itself against an identical resistance. They must be mounted on metal, which is not itself stressed, and has the same composition as the metal being investigated.

In static tests of complete airplanes, or tests made in flight, installation wiring problems must be held to a reasonable scale. In flight, the number of channels available simultaneously is restricted and means must be provided to switch from one to another.

This equipment may be put to other uses. Accelerometer pickups may be used simultaneously with strain gages. Both are ideal vibration pickups. Pressure vibrations in a hydraulic line may be picked up by a strain gage; landing wheel rotational speed indicated; spatial deflections measured.

Applications

Typical problems to which these methods may be applied are: the distribution of direct and torsional shear stresses in a multi-spar stressed skin wing; the shear lag problem arising from the shear deflection which corresponds to the shear stresses in the wing covering; the substantiation of the broad assumption that the simple bending theory applies to a beam of the complicated cross-section of a typical multi-spar cantilever wing; the nature of the transfer of load between the wing and fuselage at their intersection; the nature and seriousness of oscillations in the aircraft structure.

Difficulties involved are technical ones—due to incomplete development of equipment—and human ones—arising from the need of careful planning, organization, and patience. There must be sufficient understanding to recognize misinformation, analyze it and repeat the process until satisfactory results are achieved.

The application of this technique is not cheap or easy. The most serious problem may well be that of limiting these methods to applications reasonably sure to produce directly useful information.

—C. R. Strang, *S. A. E. Journal*, August 1942, pp. 346-347.

Radium Radiography of Castings

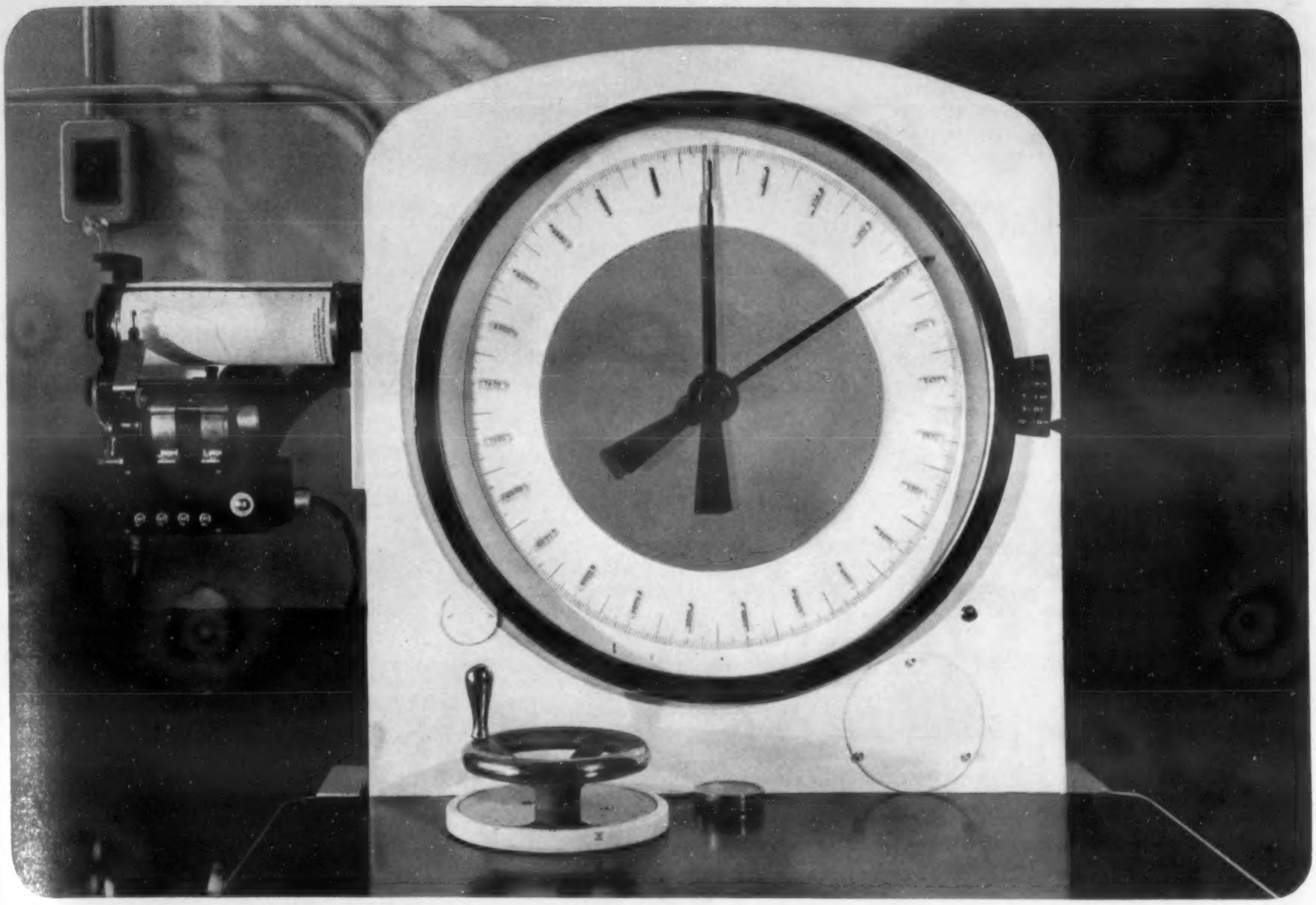
Condensed from "A.S.T.M. Bulletin"

With suitable exploitation of the emulsion characteristics of non-screen film, radium radiography provides a highly satisfactory method for examination of steel and non-ferrous metal castings from ¼ to 6 in. thick.

The first step is to segregate castings into three groups, based on the degree to which detrimental secondary radiation will be present in the radiographic image of each casting. The groups are designated as (1) "well-blocked" castings, (2) "moderately blocked" castings, and (3) "badly blocked" castings.

Usually, radium radiography is the most reliable method of examining this third group, where the shapes are such that in addition to the back scatter problem, forward transmitted scatter from thin sections of castings undercuts into the image of thick sections remote from the film, preventing a sensitive examination of thick sections.

If X-rays are used they must be heavily filtered to approximate a monochromatic beam of hard rays. A thick front lead screen is essential to reduce both obtuse scatter and the softer radiation scattered by the steel.



When using the non-screen film for radium rays, the emulsion contrast increases continuously up to a film density of over 5.0, and is maintained to densities of over 10.0. Hence a great improvement in sensitivity can be gained by using high film densities.

As to the viewing box, it is necessary to use the highest practical brightness in a box especially designed. It is necessary to reduce the area of the box until only the dense portions of the film are illuminated.

Excessive heat in the form of infra-red radiation will destroy the radiograph. The cheapest, most convenient way to get high light-to-heat ratio and high brightness is to use Photoflood lamps. White paint is preferable to metal reflectors. For high intensity boxes, one must filter the light or limit viewing time to a few seconds.

In the radiographs of many castings there are large low-density images of thick sections, together with small areas of high density images of thin sections. The edges of tilted castings often constitute effectively thin sections of this type.

The operator attempts to include all sections in one film, or use two films. One is bad because thick areas are underexposed. Two may be produced either separately, one short and one long exposure, as in X-ray practice, or in the same cassette, as in radium practice. Each is wasteful when the thin section occupies only a small area of one film. Multiple film casettes, though satisfactory, are cumbersome.

To deal with small areas of density greater than 5.0, emulsion is stripped from one side of the film, reducing density to half. A stripping tank is made with wooden walls and legs and 1/4 in. plate glass bottom. A viewing box is built under the glass. A slide carries light stops between the box and tank. Two inches of water is put in the tank. Lamps of the box warm the water to 75 deg. F.

Suitable films are taken from the processing tank and, still on film hangers, are viewed under water in the stripping tank. Areas denser than 4.0 are viewed over a small stop; then the emulsion is carefully removed from the films' upper side. A razor blade serves as a stripping tool. Next, the film is dried.

Complete images of defects that continue into thin sections can be viewed at one time.

For large castings, by combining the two-film three-lead screen technique with the stripping process one radium exposure shows up an enormous range of metal thickness. A single exposure is convenient where the radiographer places films in position at the day's end, removing them next morning.

It is unlikely that any marked increase in radium radiography sensitivity will be provided by future increases in emulsion contrast, though it may increase speed. The conception that radium is a useful inspection tool only for great thickness of metal must be abandoned. It is satisfactory for as thin as 1/4 in.

—L. W. Ball, *A. S. T. M. Bulletin*, No. 116, May 1942, pp. 29-32.

Metallography of High Test Iron

Condensed from "The Iron Age"

Grinding and polishing techniques have been developed to obtain true micro and macro structural characteristics of ordinary gray irons and Meehanite iron in both the etched and unetched condition.

Meehanite metal was cut to convenient size and ground to a flat surface on a wheel, and then ground successively through a series of emery papers. Scratches on the specimen should be very fine and uniform. Graphite flakes are covered with film of flowed metal which prevents them from being torn out during polishing.

Polishing is done by using "selvyt" cloth impregnated with magnesium oxide or "shamva" paste. During polishing the specimen is rotated in the opposite direction to that of the wheel.

After final grinding with No. 000 paper, the specimen is polished for 1/2 to 1 min. It is washed and dried with alcohol, and etched in 4% nitric acid.

Graphite flakes under the microscope appear dove gray. However it is difficult to transfer this tone quality to the photo-

graphic plate, and it has been customary to note black graphite flakes in an unetched white matrix or in an etched background of pearlite.

Accordingly the usual yellow-green filter was used. By use of backed plate in which halation is eliminated, actual visual appearance of properly polished specimen can be transferred to negative. By use of No. 4A20 glossy paper good prints were made.

To ascertain the effect of pouring temperature on tensile strength of type GA Meehanite, studies were made on changes in macrostructure of the iron. Visual studies were satisfactory but it was difficult adequately to reproduce in photographic form the characteristics visually noted.

With reproductions of etched sections within range of 1 to 10 diameters good results were obtained using Bausch and Lomb micro Tessars with vertical illumination. For reproduction of graphite distribution observed in unetched samples at about 10 diameters, the optimum condition was found in using low power Zeiss Neophot metallograph.

To make similar comparisons between pouring temperature and etched macrostructure of Meehanite a study of etching reagents and etching technique was made. This alloy is free from dendritic cementite so that etching reagents used for white irons are ineffective for development of macropattern.

The etching procedure developed by the authors consisted in rough grinding with grit Nos. 80, 120, 240 and 320, prior to etching in the following manner: (1) 2.5 gm. ammonium persulphate in 100 cc. of water, specimen swabbed for 15 min.; (2) 1.5 gm. potassium iodide added and swabbed for 10 min.; (3) 1.5 gm. mercuric chloride added and swabbed for 5 min.; and (4) 15 cc. sulphuric acid, swabbing continued for 5 min. The specimen was washed in water and dried with alcohol. Results were good and a clear picture of primary structure could be seen by visual examination.

Arbitration bars of type GA Meehanite were cast from progressively lower pouring temperatures. Tensile specimens were machined according to ASTM standard for gray iron, 0.505 diam. and 1 in. gage length. Bars were poured at 2700, 2530 and 2390 deg. F.

Transverse-etched macrostructures in the first specimens revealed a primary dendritic structure. The casting made from the highest pouring temperature showed the highest tensile strength, and showed dendrite formation in the peripheral part of the bar.

In the bar poured at the lowest temperature, a "macrostructureless" feature (freedom from dendritic pattern) is obtained. Poured at slightly higher temperature, the dendritic pattern is confined to the center.

In the case of GA Meehanite high casting temperature gives the most fully developed dendritic structure and results in optimum tensile properties.

—Charles R. Austin & M. M. Lipnick, *Iron Age*, Vol. 149, May 7, 1942, pp. 72-74; May 14, 1942, pp. 58-61, 129-130.